The Distributional Effects of COVID-19 and Mitigation Policies:

Stay-at-Home Subsidies over Stay-at-Home Orders

Sewon Hur

KAEA Macro Seminar

October, 2020

Introduction

- The COVID-19 pandemic is a public health and economic crisis, with large aggregate and distributional consequences
  - old individuals face higher fatality risk
  - young individuals face worse labor market outcomes
    - + low-wage workers are less likely to be able to work from home
    - + low-wealth workers lack the resources to weather prolonged time away from work
- This paper develops a quantitative heterogeneous-agent life-cycle economic-epidemiology model to analyze the distributional effects of the pandemic and to study various mitigation policies

Introduction

- The COVID-19 pandemic is a public health and economic crisis, with large aggregate and distributional consequences
  - old individuals face higher mortality risk
  - young individuals face worse labor market outcomes
    - + low-wage workers are less likely to be able to work from home
    - + low-wealth workers lack the resources to weather prolonged time away from work
- This paper develops a quantitative heterogeneous-agent life-cycle economic-epidemiology model to analyze the distributional effects of the pandemic and to study various mitigation policies

Preview of findings

- Without mitigation, young workers engage in too much economic activity, relative to the social optimum
  - especially true for young low-wage/wealth workers
  - leading to higher infection rates and deaths in the aggregate
- Two budget-neutral mitigation policies
- No trade-off: both policies save lives and are welfare improving
- Optimal policies involve

Preview of findings

- Without mitigation, young workers engage in too much economic activity, relative to the social optimum
- Two budget-neutral mitigation policies
  - stay-at-home subsidy that subsidizes reduced work, funded by a tax on consumption
  - stay-at-home order (lockdown) that imposes a cap on outside work hours
- No trade-off: both policies save lives and are welfare improving
- Optimal policies involve

Preview of findings

- Without mitigation, young workers engage in too much economic activity, relative to the social optimum
- Two budget-neutral mitigation policies
- Stay-at-home subsidy reduces deaths by more and output by less
  - lockdown benefits older individuals at the expense of younger low-wage workers
  - stay-at-home subsidy benefits all
- Optimal policies involve

Preview of findings

- Without mitigation, young workers engage in too much economic activity, relative to the social optimum
- Two budget-neutral mitigation policies
- Stay-at-home subsidy reduces deaths by more and output by less
- Optimal policies involve
  - longer duration subsidies (16–18 months)
  - subsidy amount depends on welfare criterion ($450–$900)
  - no lockdown

Preview of findings

- Without mitigation, young workers engage in too much economic activity, relative to the social optimum
- Two budget-neutral mitigation policies
- Stay-at-home subsidy reduces deaths by more and output by less
- Optimal policies involve
- Mitigation policies can reduce deaths and increase output

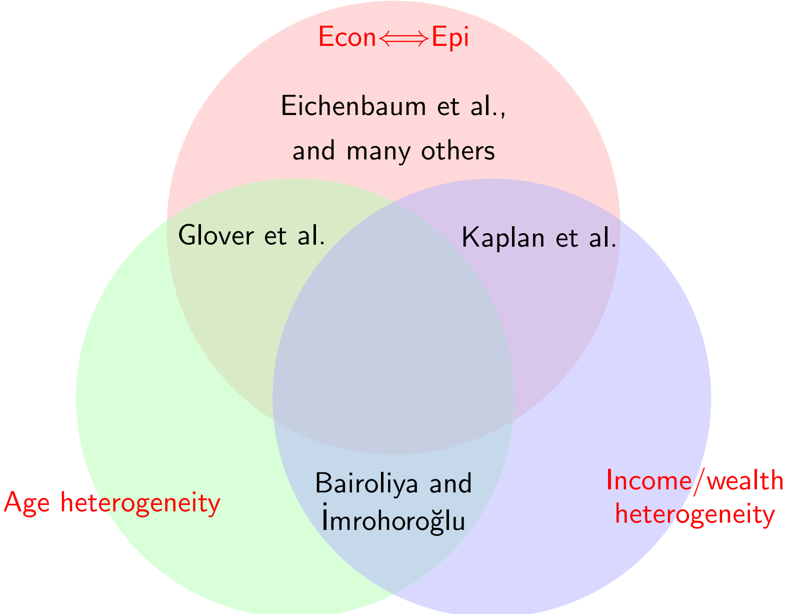
Relation to literature

Econ$\Longleftrightarrow$Epi

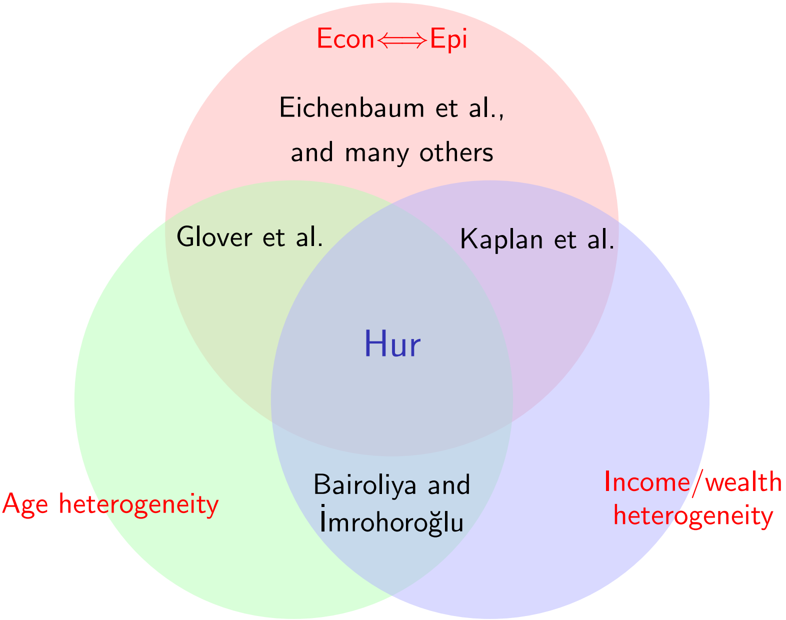
Eichenbaum et al.,

and many others

Relation to literature



Relation to literature



Model

Features of model

- Stochastic aging
- Income fluctuations + borrowing constraints + incomplete markets $\longrightarrow$ precautionary savings
- Endogenous labor supply with option to work from home
- Economic-Epidemiology model
  (economic activities $\longleftrightarrow$ virus transmission)
- Hospital capacity constraints

Demographics

- Individuals of age denoted by $j \in J \equiv \{1, 2, .., \overline{J}\}$
- Stochastic aging
  - ψ_j: probability of transitioning from age j to $j + 1$
- Retirement at $j = J^R$
- Health status $h \in \{S, I, R, D\}$
- Period utility function

Demographics

- Individuals of age denoted by $j \in J \equiv \{1, 2, .., \overline{J}\}$
- Stochastic aging
- Retirement at $j = J^R$
- Health status $h \in \{S, I, R, D\}$ for Susceptible, Infected, Recovered, and Dead
- Period utility function

Demographics

- Individuals of age denoted by $j \in J \equiv \{1, 2, .., \bar{J}\}$
- Stochastic aging
- Retirement at $j = J^R$
- Health status $h \in \{S, I, R, D\}$
- Period utility function

$$u(c, \ell, h) = \frac{c^{1-\sigma}}{1-\sigma} - \varphi \frac{\ell^{1+\nu}}{1+\nu} + \bar{u} + \hat{u}_h$$

  - c: consumption
  - ℓ: labor supply
  - $\bar{u}, \hat{u}_h$: flow value of life, health

Epidemiological block

- Build on widely used SIR model
- Susceptible individuals get infected with probability π_{It}, which depends on individual consumption and outside labor (c, ℓ^o) and the measure of infected individuals (μ_{It}) and their consumption and outside labor (C_{It}, L^o_{It})

$$\pi_{It}(c, \ell^o) = \beta_c c C_{It} + \beta_\ell \ell^o L^o_{It} + \beta_e \mu_{It}$$

- Infected individuals exit infection with probability π_X
- Recovered individuals are assumed to be immune
- Let $\Pi_{jhh't}(c, \ell^o)$ denote the transition matrix

Epidemiological block

- Build on widely used SIR model
- Susceptible individuals get infected with probability π_{It}, which depends on individual consumption and outside labor (c, ℓ^o) and the measure of infected individuals (μ_{It}) and their consumption and outside labor (C_{It}, L^o_{It})
- Infected individuals exit infection with probability π_X, then
  - recover with prob. $1 - \delta_j(\mu_{It})$
  - die with prob. $\delta_j(\mu_{It})$
- Recovered individuals are assumed to be immune
- Let $\Pi_{jhh't}(c, \ell^o)$ denote the transition matrix

Labor income

- Each period, workers receive idiosyncratic productivity shocks $\varepsilon \in E$, which follows a Markov process, with transition matrix Γ
- Their labor income is given by $w_t \eta_{jh} \varepsilon \ell$, where
  - w_t: efficiency wage
  - η_{jh}: age-profile of efficiency units (depends on health)
  - ℓ: hours worked
- A fraction $\bar{\theta}_j(\varepsilon)$ of labor can be done at home
- Retirees receive a fixed income of s each period
  - can easily depend on lifetime earnings as in Hur (2018)

Retiree's problem

- Retirees with age $j \geq J^R$, wealth k, and health h choose consumption c and savings k' to solve:

$$
\begin{aligned}
v_{jt}^R(k,h) = \max_{c,k' \geq 0} \;\; & u(c,0,h) \\
& + \beta\psi_j \sum_{h' \in H} \Pi_{jhh't}(c,0) v_{j+1,t+1}^R(k',h') \\
& + \beta(1-\psi_j) \sum_{h' \in H} \Pi_{jhh't}(c,0) v_{j,t+1}^R(k',h') \\
\text{s.t.} \;\; & (1+\tau_{ct})c + k' \leq s + k(1+r_t)
\end{aligned}
$$

  - $v_{J+1}^R = 0$
  - τ_{ct}: consumption tax
  - r_t: net return to capital

Worker's problem

- Workers with age $j < J^R$, wealth k, productivity ε, and health h choose consumption c, labor ℓ, outside labor ℓ^o, and savings k' to solve:

$$
\begin{aligned}
v_{jt}(k,\varepsilon,h) = \max_{c,\ell,\ell^o,k'\geq 0} \quad & u(c,\ell,h) + \beta \sum_{\varepsilon'\in E}\sum_{h'\in H} \Gamma_{\varepsilon,\varepsilon'} \Pi_{jhh't}(c,\ell^o) \\
& \times \begin{bmatrix} \psi_j v_{j+1,t+1}(k',\varepsilon',h') \\ + (1-\psi_j) v_{j,t+1}(k',\varepsilon',h') \end{bmatrix} \\
\text{s.t.} \quad & (1+\tau_{ct})c + k' \leq w_t \eta_{jh}(1-\tau_{\ell t})\varepsilon\ell + k(1+r_t) \\
& \left(1-\bar{\theta}_j(\varepsilon)\right)\ell \leq \ell^o \leq \ell
\end{aligned}
$$

  - Let $v_{jt}(k,\varepsilon,h) = v^R_{jt}(k,h)$ for $j \geq J^R$
  - $\tau_{\ell t}$: labor income tax

Production

- A representative firm solves

$$\max L_f^{1-\alpha} K_f^{\alpha} - w_t L_f - (r_t + \delta) K_f$$

  where L_f are effective units of labor demanded

- Optimality conditions:

$$w_t = (1-\alpha)\left(\frac{K_f}{L_f}\right)^{\alpha}$$
$$r_t = \alpha\left(\frac{K_f}{L_f}\right)^{\alpha-1} - \delta$$

Rest of talk

1. Calibrate the model in the pre-pandemic steady state

   Definition of equilibrium

2. Introduce COVID-19 into the model as an unanticipated shock
3. Solve the transition path
4. Measure the welfare effects of pandemic, with and without mitigation policies (that resemble US policies)
5. Optimal mitigation policies

Calibration

Economic parameters

- Period length: 2 weeks
- Number of age cohorts: 3 (25–44, 45–64, 65–84)
- Newborn endowments: 85% begin with zero wealth and 15% receive accidental bequests ($\sim 25\times$ annual per capita cons.)
- Share of labor that can be done from home: set to match the Dingel and Neiman (2020) share of jobs that can be done from home by occupations sorted into wage quintiles: 0.03, 0.21, 0.32, 0.47, 0.66

Economic parameters (2)

Parameters	Values	Targets / Source
Discount factor, annualized, β	0.99	Wealth-to-GDP: 4.8 (2014)
Risk aversion, σ	2	Standard value
Disutility from labor, φ	440	Average hours: 30 percent
Frisch elasticity, $1/\nu$	0.50	Standard value
Aging prob., annualized, ψ_j	0.05	Expected duration: 20 years
Efficiency units, $\eta_{1R} = \eta_{1S}$	1.00	Wage ratio of age 45–64 to
$\eta_{2R} = \eta_{2S}$	1.35	age 25–44 workers (PSID)
Factor elasticity, α	0.36	Capital share
Depreciation, annualized, δ	0.05	Standard value
Retirement income, s	1.00	30% of earnings per worker
Labor income tax, τ_ℓ	0.15	Gov't budget constraint
Consumption tax, τ_c	0.00	

Productivity shocks

- ε follows a finite-state Markov process which approximates the continuous process,

$$\log \varepsilon_t = \rho_\varepsilon \log \varepsilon_{t-1} + \nu_t,\ \nu_t \sim N\left(0, \sigma_\nu^2\right)$$

- Estimate using PSID
  - $\rho_\varepsilon = 0.94$ and $\sigma_\nu = 0.19$
  - Convert to higher frequency, following Krueger et al. (2016)

Epidemiological parameters

- Death rates: as in Piguillem and Shi (2020) and other papers, I use the functional form

$$\delta_j(\mu_I) = \delta_j^u \min\left\{1, \frac{\kappa}{\mu_I}\right\} + \delta_j^c \max\left\{0, 1 - \frac{\kappa}{\mu_I}\right\}$$

  - δ_j^u: unconstrained death rates
  - δ_j^c: untreated death rates
  - κ: measure of infected individuals that can be treated

- 924 thousand hospital beds in the US (0.28% of population)

Epidemiological parameters

- Death rates: as in Piguillem and Shi (2020) and other papers, I use the functional form

$$\delta_j(\mu_I) = \delta_j^u \min\left\{1, \frac{\kappa}{\mu_I}\right\} + \delta_j^c \max\left\{0, 1 - \frac{\kappa}{\mu_I}\right\}$$

  - δ_j^u: unconstrained death rates
  - δ_j^c: untreated death rates
  - κ: measure of infected individuals that can be treated
- 924 thousand hospital beds in the US (0.28% of population)
  - not all infected cases require hospitalization $\rightarrow \kappa = 0.01$

Epidemiological parameters (2)

Parameters	Values	Targets / Source
Infection exit rate, π_X	0.78	Expected infection duration: 18 days
Unconstrained death rate,		Fatality rates in South Korea
$\delta_1^u \times 100$	0.09	
$\delta_2^u \times 100$	0.94	
$\delta_3^u \times 100$	8.47	
Untreated death rate, δ_j^c	$2\delta_j^u$	Piguillem and Shi (2020)
Flow value of life, $\bar{u}$	9.51	Value of statistical life: \$11.5 mil. Derivation
Flow value of infection, $\hat{u}^I$	–4.57	50 percent reduction in flow utility value of average agent
Efficiency units, η_{jI}	$0.5\eta_{jS}$	

Reproduction number

- Total new infections:

$$T = \beta_c C_S C_I + \beta_\ell L_S^o L_I^o + \beta_e \mu_S \mu_I$$

- The basic reproduction number, as $\mu_I \to 0$ and assuming $C_I/\mu_I \to C_S/\mu_S$ and $L_I^o/\mu_I \to L_S^o/\mu_S$, is given by

$$R_0 = \frac{\beta_c C_S^2 + \beta_\ell L_S^2 + \beta_e}{\pi_X}$$

- Most estimates range between 2.2 and 3.1. I use $R_0 = 2.2$
- I assume that, initially, virus transmission equally likely between 3 channels (evidence from other infectious diseases: Ferguson et al. 2006, Mossong et al. 2008)

The COVID-19 crisis of 2020

Quantitative exercises

- Use the calibrated model to investigate the aggregate and distributional effects of the pandemic and mitigation policies
  - COVID-19 introduced as an unanticipated MIT-shock
  - transition path solved in partial equilibrium
    - prices fixed
    - capital and goods markets need not clear
    - gov't budget constraints (pension) need not clear
    - bequests and endowments need not clear
  - Mitigation policies are budget-neutral in present value
- First, explore how the economic-epi model of virus transmission differs from an exogenous one ($\beta_c = \beta_\ell = 0$)
- Second, compare two budget-neutral mitigation policies
- Third, explore optimal mitigation policies

Quantitative exercises

- Use the calibrated model to investigate the aggregate and distributional effects of the pandemic and mitigation policies
- First, explore how the economic-epi model of virus transmission differs from an exogenous one ($\beta_c = \beta_\ell = 0$)
  - The effects of private mitigation are large
- Second, compare two budget-neutral mitigation policies
- Third, explore optimal mitigation policies

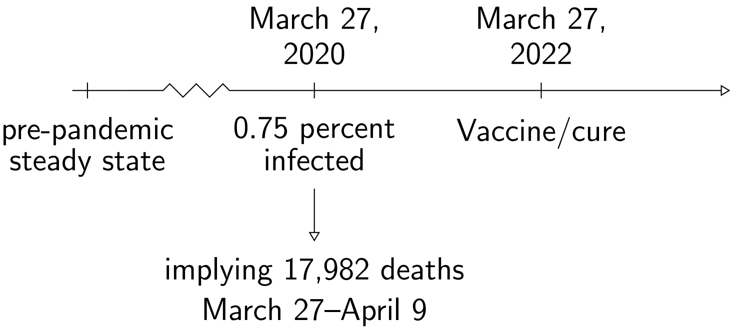
Quantitative exercises

- Use the calibrated model to investigate the aggregate and distributional effects of the pandemic and mitigation policies
- First, explore how the economic-epi model of virus transmission differs from an exogenous one ($\beta_c = \beta_\ell = 0$)
- Second, compare two budget-neutral mitigation policies
  1. *stay-at-home subsidy (subsidy)*: subsidy to individuals working less than 10 hours per week, funded by a consumption tax (e.g. PUA, PPP)
  2. *stay-at-home order (lockdown)*: impose a cap of 10 outside work hours per week
- Third, explore optimal mitigation policies

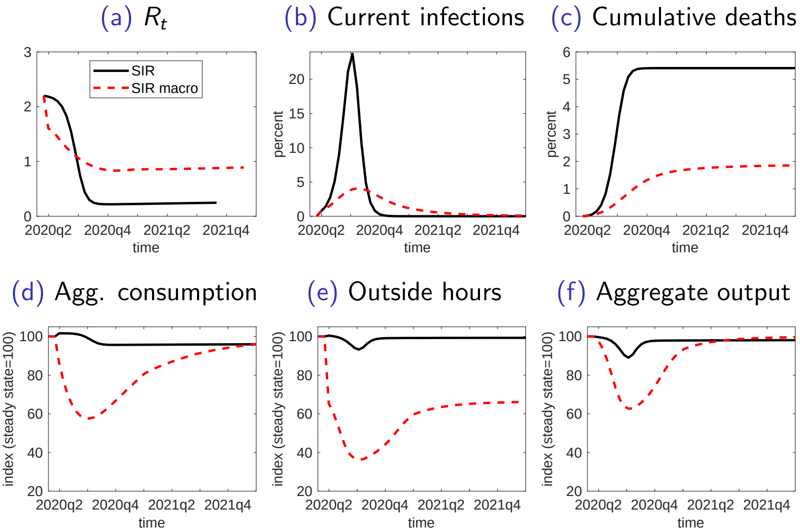
Quantitative exercises

- Use the calibrated model to investigate the aggregate and distributional effects of the pandemic and mitigation policies
- First, explore how the economic-epi model of virus transmission differs from an exogenous one ($\beta_c = \beta_\ell = 0$)
- Second, compare two budget-neutral mitigation policies
- Third, explore optimal mitigation policies

Timeline (without mitigation policy)



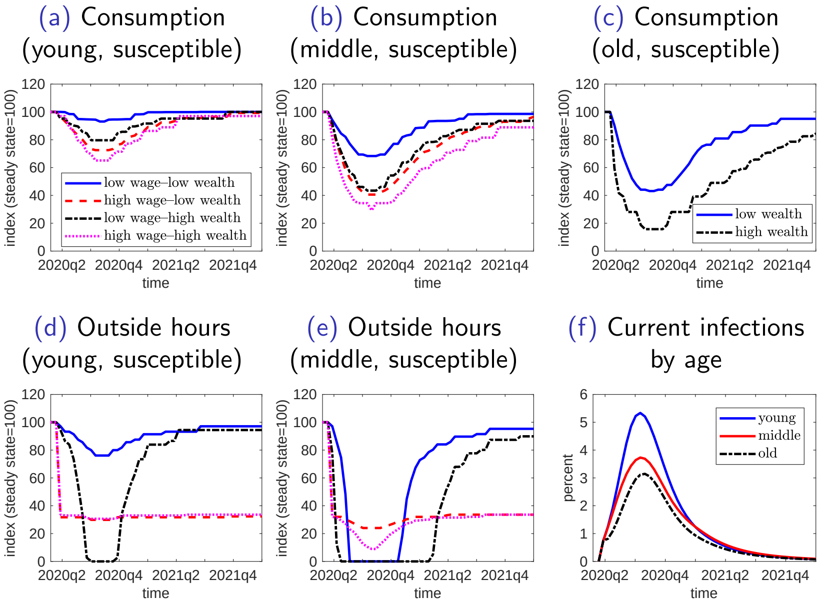
Private mitigation is large



Private mitigation is large

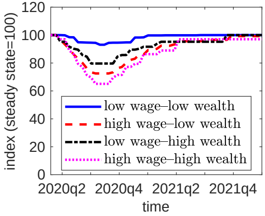
- Let's now consider the policy functions of low/high wage/wealth individuals (no mitigation policy)

Reduction in economic activities is broad-based ...

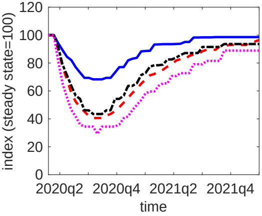


... but smallest for young low wage/wealth workers

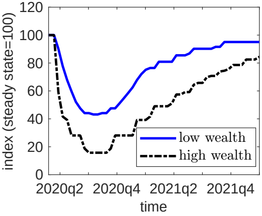
(a) Consumption (young, susceptible)



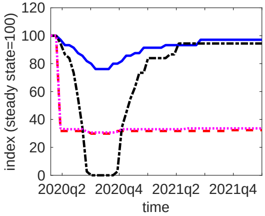
(b) Consumption (middle, susceptible)



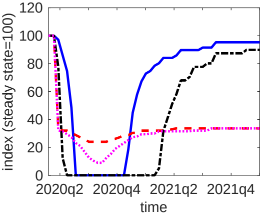
(c) Consumption (old, susceptible)



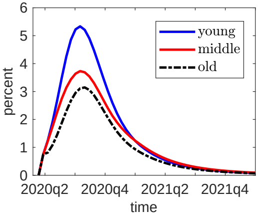
(d) Outside hours (young, susceptible)



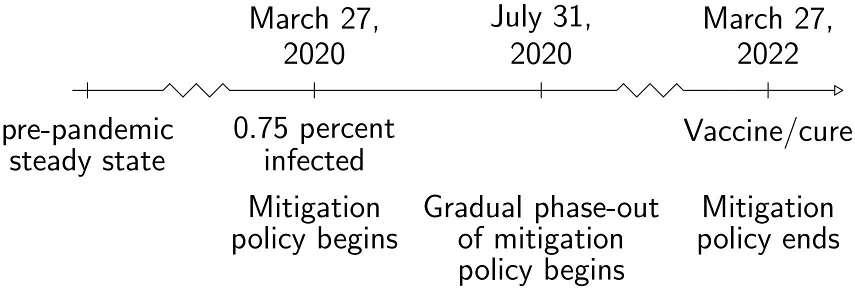
(e) Outside hours (middle, susceptible)



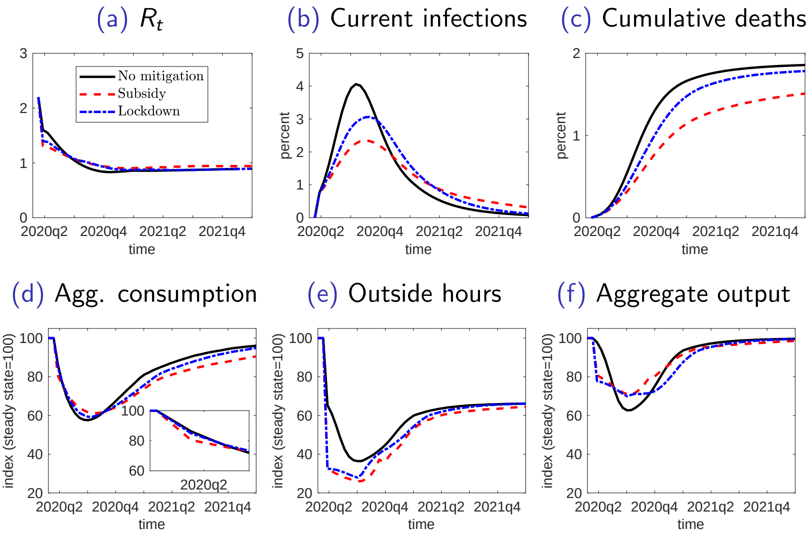
(f) Current infections by age



Timeline (with mitigation policies)



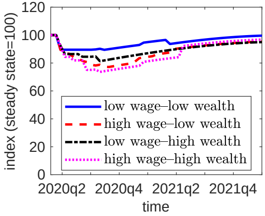
With and without mitigation policies



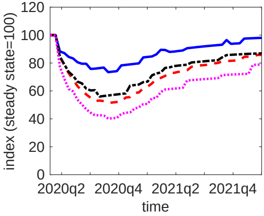
Response to pandemic (subsidy)

▸ lockdown

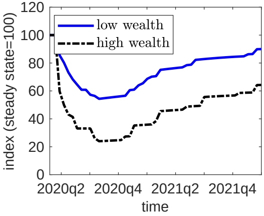
(a) Consumption (young, susceptible)



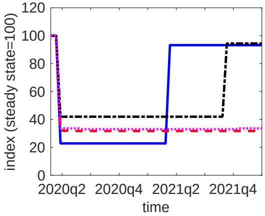
(b) Consumption (middle, susceptible)



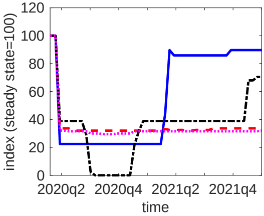
(c) Consumption (old, susceptible)



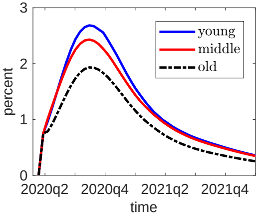
(d) Outside hours (young, susceptible)



(e) Outside hours (middle, susceptible)



(f) Current infections by age



Welfare effects of pandemic and mitigation policies

	consumption equivalents (percent)					policy
wealth	low		high		average	support
wage	low	high	low	high		(percent)
no mitigation					−19.6	
young	−2.6	−3.6	−3.8	−4.7		
middle	−11.4	−14.7	−15.2	−20.4		
old	−30.3		−46.0			

Welfare effects of pandemic and mitigation policies

	consumption equivalents (percent)					policy
wealth	low		high		average	support
wage	low	high	low	high		(percent)
no mitigation					–19.6	
young	–2.6	–3.6	–3.8	–4.7		
middle	–11.4	–14.7	–15.2	–20.4		
old	–30.3		–46.0			
stay-at-home subsidy					–17.2	100.0
young	–2.2	–3.5	–3.2	–4.4		
middle	–9.1	–12.5	–13.0	–18.0		
old	–26.3		–41.5			
stay-at-home order					–19.4	73.6
young	–4.3	–3.7	–3.8	–4.6		
middle	–11.8	–14.5	–15.0	–20.1		
old	–29.3		–45.0			

Optimal Policies

Optimal Policies

- Investigate the properties of optimal mitigation policies, within a limited set of instruments
  - subsidy amount
  - duration
  - hours threshold
  - lockdown
- Among policies that have full support (i.e. Pareto improvements), optimal policy involves
- Output maximizing policy involves

Optimal Policies

- Investigate the properties of optimal mitigation policies, within a limited set of instruments
- Among policies that have full support (i.e. Pareto improvements), optimal policy involves
  - larger subsidy amount ($\sim$ \$900)
  - longer duration ($\sim$ 18 months)
  - lower hours threshold (0)
  - no lockdown
- Output maximizing policy involves

Optimal Policies

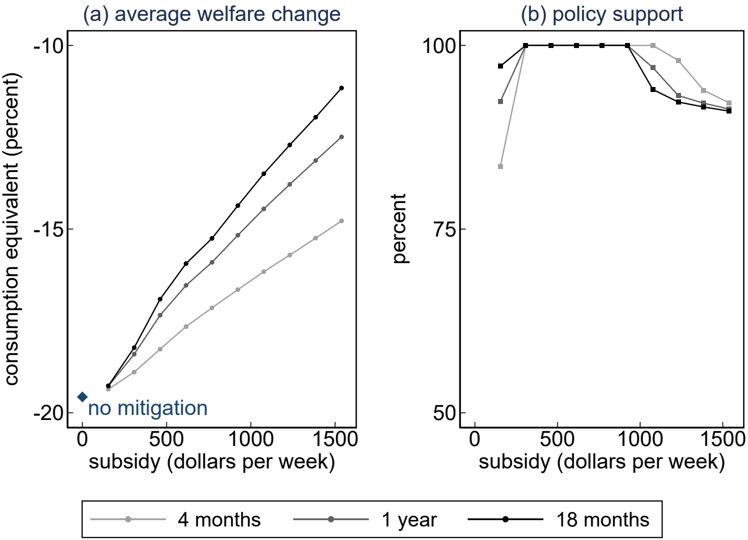
- Investigate the properties of optimal mitigation policies, within a limited set of instruments
- Among policies that have full support (i.e. Pareto improvements), optimal policy involves
- Output maximizing policy involves
  - smaller subsidy amount ($\sim$ \$450)
  - longer duration ($\sim$ 16 months)
  - lower hours threshold (0)
  - no lockdown

Policy configurations

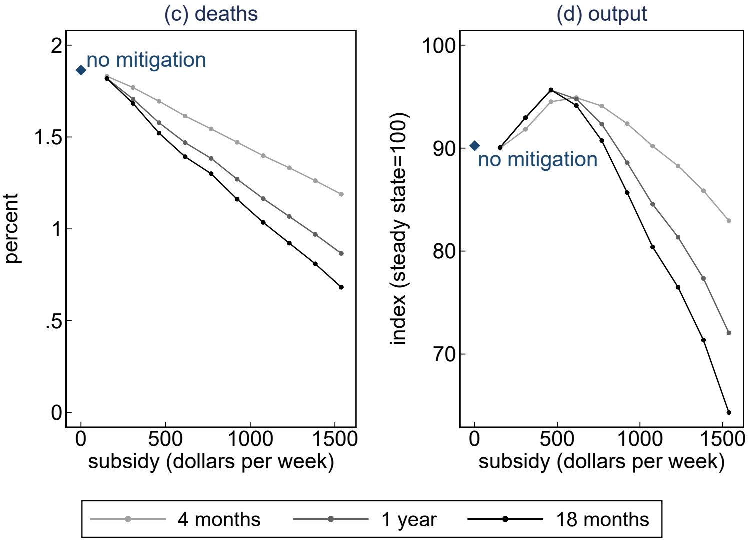
	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	900	18	0	no	–14.4	85.7	1.2
output maximizing*							
	450	16	0	no	–17.0	95.7	1.5
US policy							
	600	4	10	yes	–17.2	87.9	1.5
no mitigation							
	0	0	none	no	–19.6	90.2	1.9

- *: Pareto improvements relative to no mitigation
- Robust to ▸ lower vsl ▸ smaller infection utility loss ▸ smaller infection productivity loss ▸ larger hospital capacity ▸ earlier vaccine ▸ tax on consumption and labor income ▸ home consumption ▸ transmission only through economic activities

Larger & longer subsidies improve welfare ...

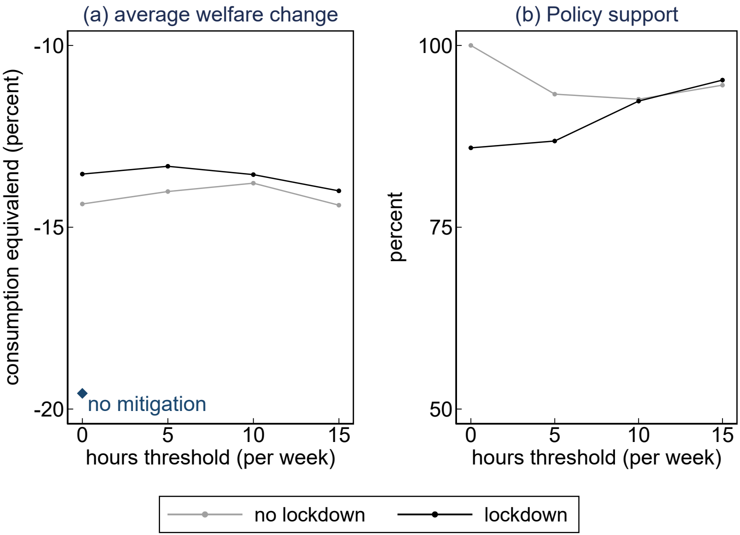


... lead to less deaths and *possibly* lower output

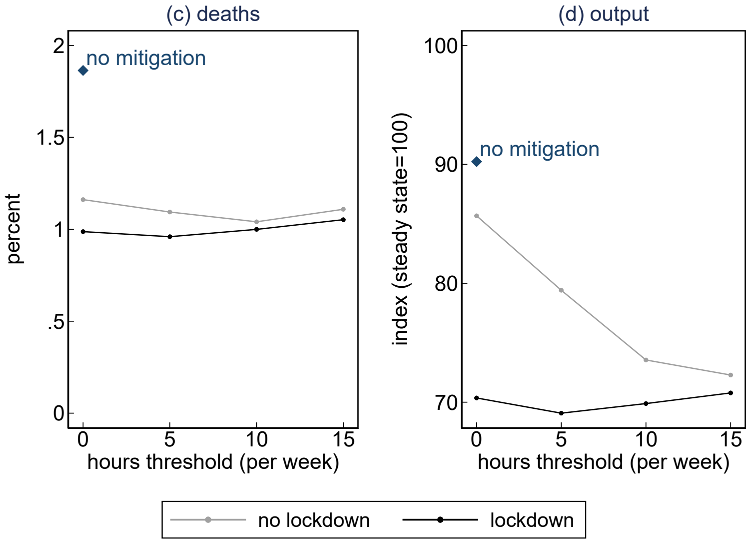


Lockdowns slightly improve average welfare ...

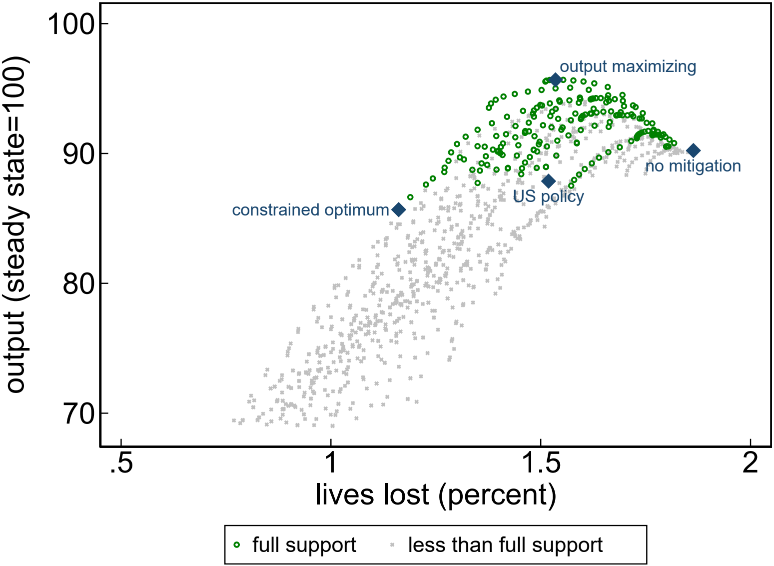
- not fully supported



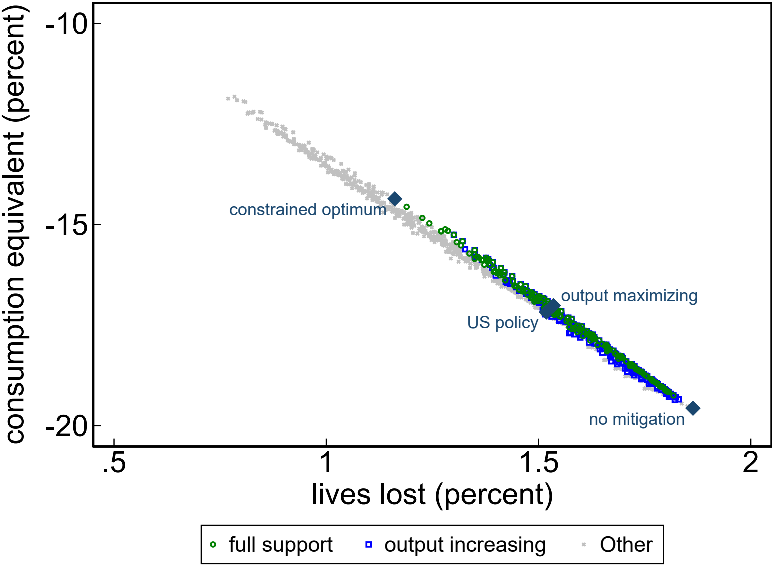
... but steeply reduces output



Not necessarily a trade-off between lives and output



No trade-off between lives and welfare



Conclusion

- Quantitative life-cycle economic-epidemiology model
  - measure the heterogeneous welfare effects of COVID-19
  - evaluate mitigation policies
- Stay-at-home subsidies dominate stay-at-home orders
- Optimal mitigation policies involve longer duration subsidies and no lockdowns
- There need not be a tradeoff between saving lives and output/welfare

Appendix

Equilibrium ▸ back

- Let $X = K \times E \times H$ denote the state space over wealth, productivity, and health
- Let a σ-algebra over X defined by the Borel sets, $\mathcal{B}$, on X.
- A *steady-state recursive equilibrium*, given fiscal policies $\{\tau_c, \tau_\ell, s\}$, is
  - value functions $\{v_j\}_{j \in J}$,
  - policy functions $\{c_j, \ell_j, \ell_j^o, k_j'\}_j$,
  - producer plans $\{Y_f, L_f, K_f\}$
  - prices $\{w, r\}$,
  - distribution of newborns ω
  - invariant measures $\{\mu_j\}_j$

  such that:

Equilibrium (2) ‣ back

1. Given prices, workers and retirees optimize
2. Given prices, firms optimize
3. Goods and factor markets clear
4. Government budget holds:

$$
\begin{aligned}
s \int_X \sum_{j \geq J^R} d\mu_j(k,\varepsilon,h) = & \tau_\ell \int_X \sum_{j < J^R} w \eta_{jh} \varepsilon \ell_j(k,\varepsilon,h) d\mu_j(k,\varepsilon,h) \\
& + \tau_c \int_X \sum_{j \in J} c_j(k,\varepsilon,h) d\mu_j(k,\varepsilon,h)
\end{aligned}
$$

Equilibrium (3) back

5. for any $(\mathcal{K}, \mathcal{E}, \mathcal{H}) \in \mathcal{B}$, the invariant measure μ_j satisfies

$$\mu_j(\mathcal{K}, \mathcal{E}, \mathcal{H}) = \int_X \psi_{j-1} \mathbb{1}_{\{k'_{j-1}(k,\varepsilon,h)\in\mathcal{K}\}} \sum_{\varepsilon'\in\mathcal{E}} \sum_{h'\in\mathcal{H}} \Gamma_{\varepsilon,\varepsilon'} \Pi_{jhh'} d\mu_{j-1}(k,\varepsilon,h)$$
$$+ \int_X (1-\psi_j) \mathbb{1}_{\{k'_{j+1}(k,\varepsilon,h)\in\mathcal{K}\}} \sum_{\varepsilon'\in\mathcal{E}} \sum_{h'\in\mathcal{H}} \Gamma_{\varepsilon,\varepsilon'} \Pi_{jhh'} d\mu_j(k,\varepsilon,h)$$

and

$$\mu_1(\mathcal{K}, \mathcal{E}, \mathcal{H}) = \int_X (1-\psi_1) \mathbb{1}_{\{k'_1(k,\varepsilon,h)\in\mathcal{K}\}} \sum_{\varepsilon'\in\mathcal{E}} \sum_{h'\in\mathcal{H}} \Gamma_{\varepsilon\varepsilon'} \Pi_{hh'} d\mu_1(k,\varepsilon,h)$$
$$+ \omega(\mathcal{K}, \mathcal{E}, \mathcal{H})$$

Equilibrium (4) ▸ back

6. The newborn distribution satisfies:

$$\int_X k d\omega(k, \varepsilon, h) = \int_X \psi_{\bar{J}} k'_{\bar{J}}(k, \varepsilon, h) d\mu_{\bar{J}}(k, \varepsilon, h)$$

Derivation of $\bar{u}$ ‣ back

- Assume that the VSL is computed based on the consumption of an infinitely-lived representative agent that discounts time at the rate of $\beta(1-\psi)$ in the pre-pandemic steady state, whose present discounted utility is given by

$$v = \frac{(\bar{c}+\Delta_c)^{1-\sigma}}{1-\sigma} + \bar{u} + \frac{\beta(1-\psi+\Delta_\psi)}{1-\beta(1-\psi)}\left(\frac{\bar{c}^{1-\sigma}}{1-\sigma} + \bar{u}\right)$$

  - $\bar{c}$: steady state consumption per capita
  - Δ_c, Δ_ψ: small one-time deviations to consumption and survival probability

Derivation of $\bar{u}$ (2) back

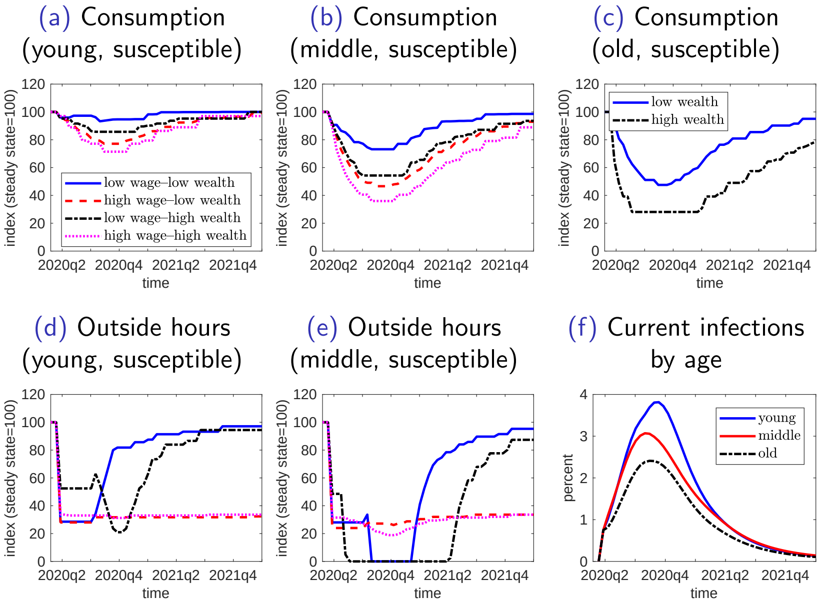
- The VSL—defined as the marginal rate of substitution between survival and consumption—can be expressed as

$$VSL = \left.\frac{\frac{\partial v}{\partial \Delta_\psi}}{\frac{\partial v}{\partial \Delta_c}}\right|_{\Delta_c=0} = \frac{\beta}{1-\beta(1-\psi)} \frac{\frac{\bar{c}^{1-\sigma}}{1-\sigma}+\bar{u}}{\bar{c}^{-\sigma}}$$

- By substituting $VSL = 7475 \times \bar{c}$, we obtain

$$\bar{u} = 7475 \times \bar{c}^{1-\sigma} \frac{1-\beta(1-\psi)}{\beta} - \frac{\bar{c}^{1-\sigma}}{1-\sigma}$$

Response to pandemic (lockdown) ▸ back



Lower vsl ($vsl = 6208\bar{c}$) back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	750	22	0	no	–13.7	89.5	1.4
output maximizing*							
	450	14	0	no	–15.5	96.1	1.6
US policy							
	600	4	10	yes	–15.6	88.5	1.6
no mitigation							
	0	0	none	no	–17.7	91.4	2.0

- *: Pareto improvements relative to no mitigation

Smaller infection utility loss ($\hat{u}_I = -2.74$) ▸ back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	750	22	0	no	–15.0	89.5	1.3
output maximizing*							
	450	14	0	no	–17.0	95.8	1.6
US policy							
	600	4	10	yes	–17.1	88.1	1.5
no mitigation							
	0	0	none	no	–19.4	90.6	1.9

- *: Pareto improvements relative to no mitigation

Smaller infection efficiency loss ($\eta_{jI} = 0.7\eta_{jS}$) ▸ back

	subsidy amount (\$/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	750	22	0	no	–15.6	86.8	1.3
output maximizing*							
	600	10	0	no	–17.6	91.4	1.6
US policy							
	600	4	10	yes	–17.8	86.1	1.6
no mitigation							
	0	0	none	no	–19.8	89.5	1.9

- *: Pareto improvements relative to no mitigation

Larger hospital capacity ($\kappa = 0.015$) ▸ back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	900	18	0	no	–13.3	85.7	1.0
output maximizing*							
	450	14	0	no	–16.1	96.0	1.4
US policy							
	600	4	10	yes	–16.0	88.4	1.4
no mitigation							
	0	0	none	no	–18.6	90.1	1.7

- *: Pareto improvements relative to no mitigation

Earlier vaccine (March 27, 2021) ▸ back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	1500	10	5	yes	–8.0	77.6	0.5
output maximizing*							
	450	12	0	no	–15.2	96.5	1.3
US policy							
	600	4	10	yes	–15.3	88.5	1.3
no mitigation							
	0	0	none	no	–18.5	90.4	1.7

- *: Pareto improvements relative to no mitigation

Tax on consumption and labor income

back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	750	22	0	no	–13.7	89.5	1.4
output maximizing*							
	450	14	0	no	–15.5	96.1	1.6
US policy							
	600	4	10	yes	–15.6	88.5	1.6
no mitigation							
	0	0	none	no	–17.7	91.4	2.0

- *: Pareto improvements relative to no mitigation

Home consumption ▸ back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*							
	900	22	0	no	–10.3	83.2	0.7
output maximizing*							
	450	22	0	no	–11.2	95.9	0.8
US policy							
	600	4	10	yes	–12.6	88.1	1.0
no mitigation							
	0	0	none	no	–14.8	90.1	1.2

- *: Pareto improvements relative to no mitigation

Transmission only through economic activities ($\beta_e = 0$) ▸ back

	subsidy amount ($/wk)	duration (months)	thres-hold (hours /week)	lock-down	average welfare change (%)	2-year output (index)	deaths (%)
constrained optimum*	1050	18	0	no	–2.9	81.2	0.1
output maximizing*	450	22	0	no	–5.1	97.1	0.3
US policy	600	4	10	yes	–6.7	87.5	0.4
no mitigation	0	0	none	no	–8.7	91.0	0.5

- *: Pareto improvements relative to no mitigation