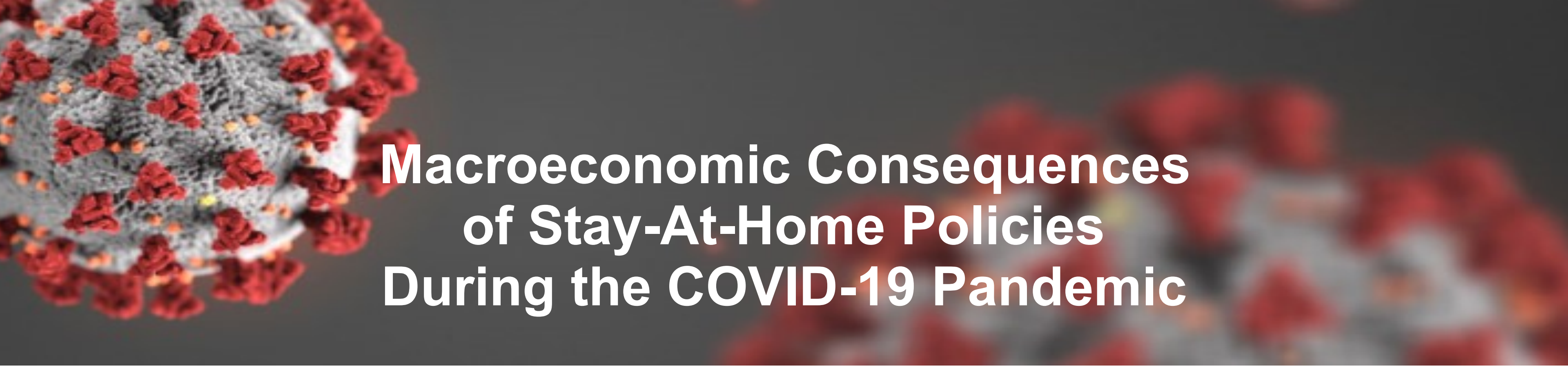


Macroeconomic Consequences of Stay-At-Home Policies During the COVID-19 Pandemic

Neha Bairoliya Ayşe İmrohoroğlu

University of Southern California

December 2021

Introduction

- COVID-19: Unprecedented public health and economic crisis

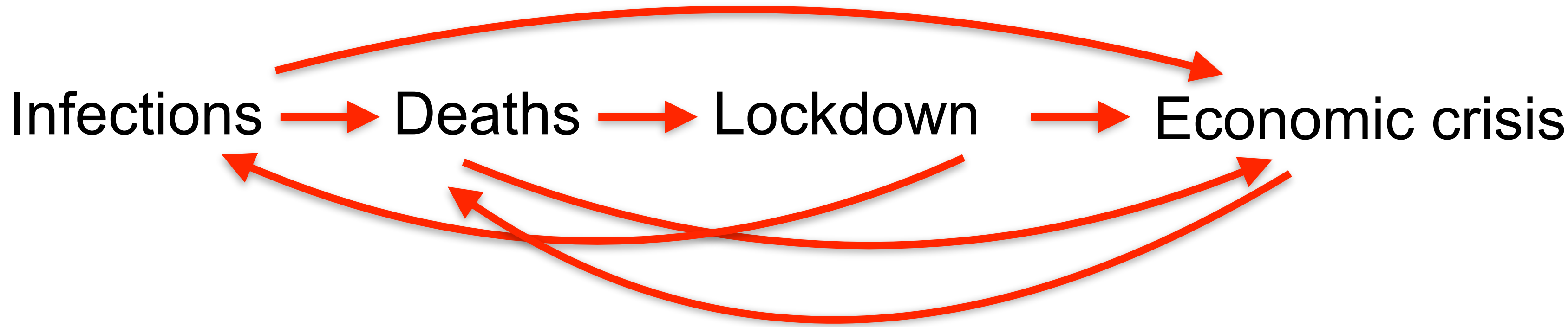
Infections → Deaths → Lockdown → Economic crisis

Introduction

- COVID-19: Unprecedented public health and economic crisis

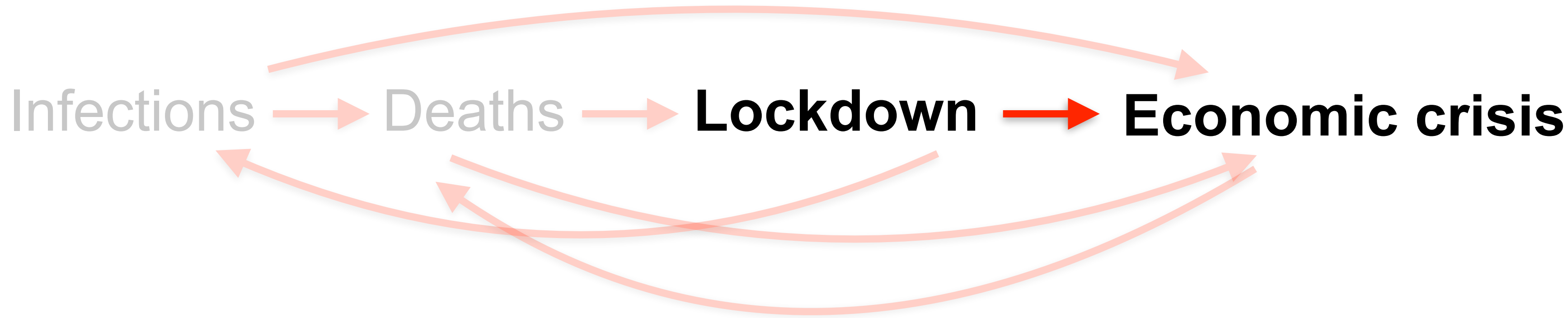
Introduction

- COVID-19: Unprecedented public health and economic crisis



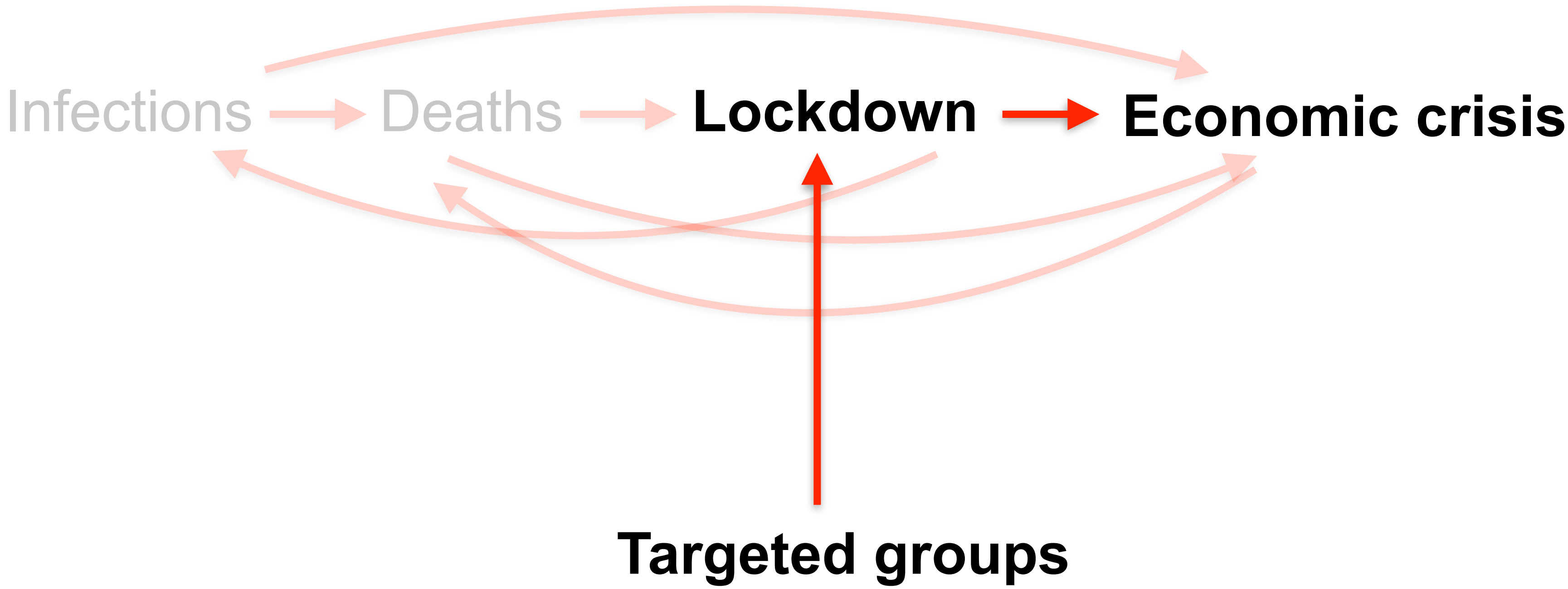
Introduction

- COVID-19: Unprecedented public health and economic crisis



Introduction

- COVID-19: Unprecedented public health and economic crisis



This paper

- For a given infection scenario: what are the benefits of a targeted lockdown?

- Can individuals be convinced to self-isolate through economic incentives?
  - How large are the required transfers?
  - How does it vary by socio-economic/health groups?

This paper

- For a given infection scenario: what are the benefits of a targeted lockdown?

  lockdown based on health → 22.5% lesser decline in output.

- Can individuals be convinced to self-isolate through economic incentives?

  - How large are the payoffs?

  - How does it vary by socio-economic/health groups?

This paper

- For a given infection scenario: what are the benefits of a targeted lockdown?

  lockdown based on health → 22.5% lesser decline in output.

- Can individuals be convinced to self-isolate through economic incentives?

  - How large are the payoffs?

    1.32% of GDP to isolate all vulnerable individuals.

  - How does it vary by socio-economic/health groups?

    Older, wealthy individuals self-mitigate. Wealth poor require significant transfers → 35 to 50% of their labor earnings.

Outline

- Motivation and background
- Model
- Data & Calibration
- Results
- Robustness Checks
- Conclusions

Environment

- Overlapping generations of agents living J(80) periods
- Each period a new generation is born at rate *n*
- Individuals are characterized by health status *h*
  - which evolves stochastically over the life- cycle
  - and is a function of age, and level of education
- Health affects labor productivity and mortality
- Earnings depends on age, education, health, hours worked and idiosyncratic shocks

COVID-19

- Model economy starts with an initial steady state
  - In transition, a new generation of 20-year-old is born every year

- COVID-19

  – Unexpected health shock hits in 2020 (first transition period)
  – Timeline of the shock:

  – If infected labor productivity declines
  – If infected survival probability declines (by age)
  – Mandatory lockdowns in 2020

COVID-19

- Model economy starts with an initial steady state
  - In transition, a new generation of 20-year-old is born every year

- COVID-19
  - Unexpected health shock hits in 2020 (first transition period)
  - Timeline of the shock:

t=1
Exogenous shock, workers affected more than retirees

t=2
Infection risk persists, endogenous mitigation possible through labor market activity

t=3
Vaccine is available. No more new infections. Additional deaths due to t=2 infections realized

t=4
Pre-COVID world*
(*altered demographics)

  - If infected labor productivity declines
  - If infected survival probability declines (by age)
  - Mandatory lockdowns in t=1

Model: Government

- Labor income tax (τ_l) funds Social Security.
- Introduces Pandemic Assistance after COVID-19.
- Imposes lockdown on some fraction of the population as part of the mitigation measure.

Model: Technology

- Output is produced by a representative firm using the technology:

$$Y_t = A_t K N_t^{1-\alpha}$$

Model: Households

- Agents maximize utility over consumption and leisure.
- State variables initial steady state: $z = (a, \eta, j, e, h)$
- State variables after COVID-19: $\tilde{z} = (a, \eta, j, e, h, x, q)$
  - current holdings of one-period, risk-free assets (a)
  - stochastic labor productivity (η)
  - age (j)
  - fixed education (e)
  - stochastic health shock (h)
  - infection status ($x = 0$ not infected; $x = 1$ infected)
  - quarantine status ($q = 0$ not quarantined; $q = 1$ quarantined)
- Agents face mortality risk: (ψ_{jeh})

Decision Problem

$$V_t(z) = \max_{c_t, l_t, a'_t} \left\{ u(c_t, l_t) + \beta\psi_{jeh} \int V_{t+1}(z')\Phi_{t+1}(\eta', h')d(\eta', h') \right\}$$

subject to:

$$c_t + a'_t = y_{j,t} + (1 + r_t)\left(a_t + Tr_t\right),$$

$$y_{j,t} = \begin{cases} w_t\left(1 - \tau_t^{\ell}\right)\epsilon_{je}\xi_h\eta l_t & \text{if} \quad j < j_r \\ SS_{e,t} & \text{if} \quad j \geq j_r \end{cases}$$

$$a' \geq 0, \; c \geq 0, \; 0 \leq \ell \leq 1$$

Decision Problem

$$V_t(\widetilde{z}) = \max_{c_t, l_t, a'_t} \left\{ u(c_t, l_t) + \beta \psi_{jehx} \sum_{x'} \Pi_t(x'_t | x_t, l'_t) \int V_{t+1}(\widetilde{z'}) \Phi_{t+1}(\eta', h') d(\eta', h') \right\}$$

subject to:

$$c_t + a'_t = y_{j,t} + (1 + r_t)\Big(a_t + Tr_t\,(j = 1)\Big),$$

$$y_{j,t} = \begin{cases} w_t\left(1 - \tau_t^{\ell}\right)\epsilon_{je}\xi_h \eta l_t & \text{if} \quad j < j_r \quad \& \quad q_t = 0, x_t = 0, \forall t \\ w_t\left(1 - \tau_t^{\ell}\right)\epsilon_{je}\xi_h \theta_x \eta l_t & \text{if} \quad j < j_r \quad \& \quad q_t = 0, x_t = 1, t = 1,2 \\ PA_t & \text{if} \quad j < j_r \quad \& \quad q_t = 1, \forall x_t,\ t = 1 \\ SS_{e,t} & \text{if} \quad j \geq j_r \quad \forall q_t, \forall x_t, \forall t \end{cases}$$

$$a' \geq 0, c \geq \underline{c}, 0 \leq \ell \leq 1$$

Outline

- Motivation and background
- Model
- Data & Calibration
- Results
- Robustness Checks
- Conclusions

Calibration:Health and Education

- Education takes two values:
  {College, Non-College}

- Health can take three possible values:
  {Excellent, Good, Poor}

- Constructed using Medical Expenditure Panel Survey (MEPS):
  Self reported health

- Health transitions estimated using ordered probit regressions.

- Survival probabilities vary with age, education and health status
  1. unadjusted probabilities estimated MEPS using probit regressions
  2. adjustments:
     - survival probabilities in the National Vital Statistics System data
     - education survival premium

Calibration:Economic Parameters

	Value	Source/Target
Model period	1 year	
Cohort growth (n)	1.8%	Dependency ratio=28%
Retirement age (j_r)	65	Social Security NRA
Discount factor (β)	0.96	K/Y=3.0
Risk aversion (σ)	3.56	IES=0.5
Consumption weight (γ)	0.39	Average hours=0.33
Utility scale $(\bar{u})$	30.0	VSL = $11 million
Persistence (ρ)	0.83	Fuster et al. (2007)
Variance (σ_η^2)	0.022	Fuster et al. (2007)
Poor health cost (ξ_{poor})	0.63	MEPS
Good health cost (ξ_{good})	0.86	MEPS
Excellent health cost $(\xi_{excellent})$	1.0	MEPS
Capital income share (α)	0.36	
Depreciation rate (δ)	5.9%	
Social Security replacement rate	44%	Fuster et al. (2007)
Pandemic assistance (PA)	25% average income	

Calibration:Economic Parameters

	Value	Source/Target
Model period	1 year	
Cohort growth (n)	1.8%	Dependency ratio=28%
Retirement age (j_r)	65	Social Security NRA
Discount factor (β)	0.96	K/Y=3.0
Risk aversion (σ)	3.56	IES=0.5
Consumption weight (γ)	0.39	Average hours=0.33
Utility scale $(\bar{u})$	30.0	VSL = $11 million
Persistence (ρ)	0.83	Fuster et al. (2007)
Variance (σ_η^2)	0.022	Fuster et al. (2007)
Poor health cost (ξ_{poor})	0.63	MEPS
Good health cost (ξ_{good})	0.86	MEPS
Excellent health cost $(\xi_{excellent})$	1.0	MEPS
Capital income share (α)	0.36	
Depreciation rate (δ)	5.9%	
Social Security replacement rate	44%	Fuster et al. (2007)
Pandemic assistance (PA)	25% average income	

$$u\left(c_j, \ell_j\right) = \frac{\left[c_j^{\gamma}\left(1-\ell_j\right)^{1-\gamma}\right]^{1-\sigma}}{1-\sigma} + \bar{u}$$

Calibration:Economic Parameters

	Value	Source/Target
Model period	1 year	
Cohort growth (n)	1.8%	Dependency ratio=28%
Retirement age (j_r)	65	Social Security NRA
Discount factor (β)	0.96	K/Y=3.0
Risk aversion (σ)	3.56	IES=0.5
Consumption weight (γ)	0.39	Average hours=0.33
Utility scale $(\bar{u})$	30.0	VSL = $11 million
Persistence (ρ)	0.83	Fuster et al. (2007)
Variance (σ_η^2)	0.022	Fuster et al. (2007)
Poor health cost (ξ_{poor})	0.63	MEPS
Good health cost (ξ_{good})	0.86	MEPS
Excellent health cost $(\xi_{excellent})$	1.0	MEPS
Capital income share (α)	0.36	
Depreciation rate (δ)	5.9%	
Social Security replacement rate	44%	Fuster et al. (2007)
Pandemic assistance (PA)	25% average income	

$$\ln\left(\eta'\right) = \rho \ln\left(\eta\right) + \epsilon_\eta, \quad \epsilon_\eta \sim N\left(0,\sigma_\eta^2\right).$$

COVID-19 Parameters

- Infection shock is calibrated to a projected 363,269 deaths in 2020. Fatality rate 0.3%, death rate 0.11% → 36.9% infection rate

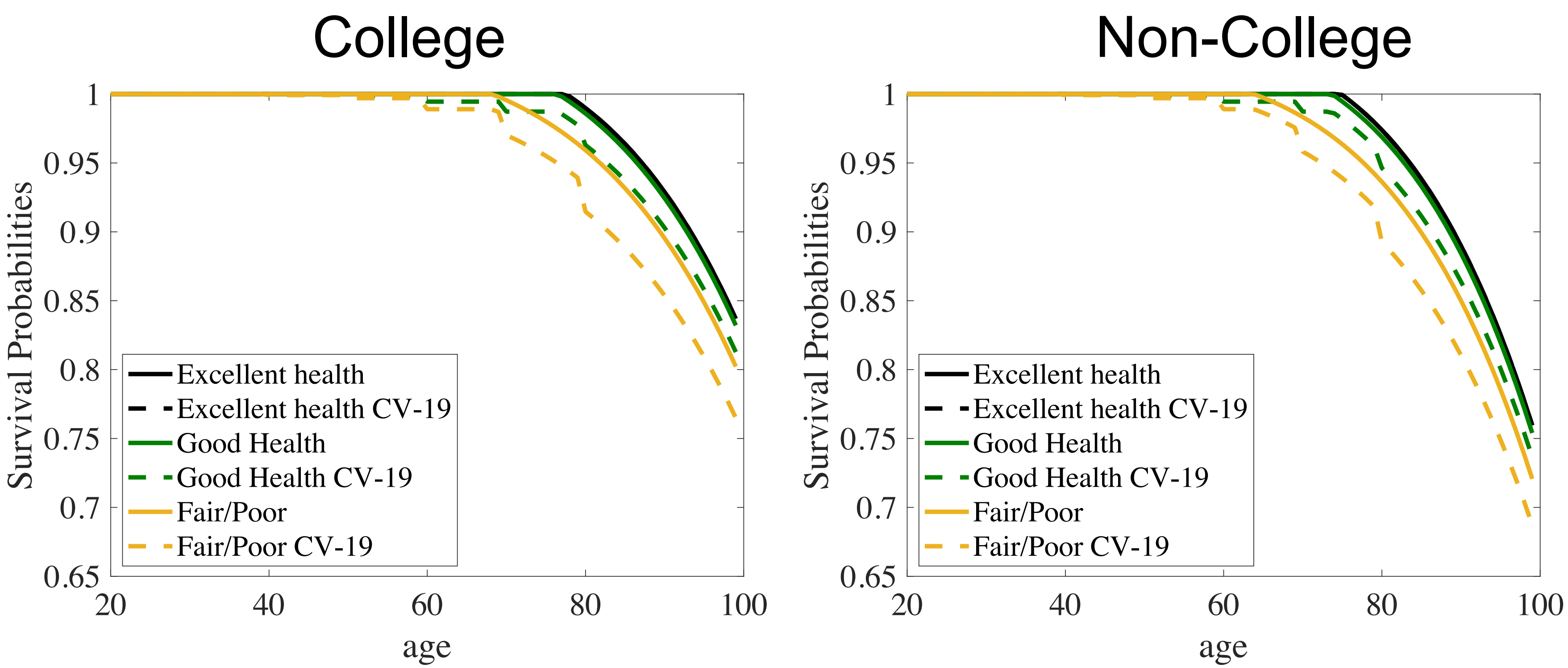
COVID-19 Parameters

Fatality Rate = 0.3%

	Fatality rate (%)*	Age-specific scale**
20-29	0.03	0
30-39	0.08	0
40-49	0.15	1.0x
50-59	0.60	4.0x
60-69	2.2	14.7x
70-79	5.1	34.0x
80+	9.3	62.0x

*Ferguson et al. (2020)
**x differs by health state, x=0.000750 for those in *poor* health and x=0.000375 for those in *good* health states.

COVID-19 Parameters



COVID-19 Parameters

- Infection shock is calibrated to a projected 363,269 deaths in 2020.
  Fatality rate 0.3%, death rate 0.11% → 36.9% infection rate
- 35% higher risk of infections for workers.
- 18.4% infection risk in the 2021 period calibrated to 181,634 deaths
- No re-infection risk

COVID-19 : Infection Transition Probability

$$\Pi_t(x_t \,|\, x_{t-1}, l_t)$$

	$t = 2$					$t \geq 3$	
	$l_2 > 0$		$l_2 = 0$			$l_t \geq 0$	
	$x_2 = 0$	$x_2 = 1$	$x_2 = 0$	$x_2 = 1$		$x_t = 0$	$x_t = 1$
$x_1 = 0$	0.80	0.20	0.87	0.13	$x_{t-1} = 0$	1.0	0.0
$x_1 = 1$	1.0	0.0	1.0	0.0	$x_{t-1} = 1$	1.0	0.0

*Ferguson et al. (2020)
**x differs by health state, x=0.000750 for those in *poor* health and x=0.000375 for those in *good* health states.

COVID-19 : Infection Transition Probability

$$\Pi_t(x_t \mid x_{t-1}, l_t)$$

	$t = 2$					$t \geq 3$	
	$l_2 > 0$		$l_2 = 0$			$l_t \geq 0$	
	$x_2 = 0$	$x_2 = 1$	$x_2 = 0$	$x_2 = 1$		$x_t = 0$	$x_t = 1$
$x_1 = 0$	0.80	**0.20**	0.87	**0.13**	$x_{t-1} = 0$	1.0	0.0
$x_1 = 1$	1.0	0.0	1.0	0.0	$x_{t-1} = 1$	1.0	0.0

*Ferguson et al. (2020)
**x differs by health state, x=0.000750 for those in *poor* health and x=0.000375 for those in *good* health states.

COVID-19 Parameters

- Infection shock is calibrated to a projected 363,269 deaths in 2020. Fatality rate 0.3%, death rate 0.11% → 36.9% infection rate
- 35% higher risk of infections for workers.
- 18.4% infection risk in the 2021 period calibrated to 181,634 deaths
- No re-infection risk
- 11.4% working age population quarantined in 2020
- Infection results in zero productivity for 18 days
  - annual productivity loss 5%

Outline

- Motivation and background
- Model
- Data & Calibration
- Results
- Robustness Checks
- Conclusions

Model Fit: Initial Steady State

Age-Health Distribution

	Model			Data		
	Excellent	Good	Poor	Excellent	Good	Poor
18-44	34.3	58.2	7.4	37.4	56.5	6.1
45-64	21.0	64.9	14.0	22.4	62.3	15.3
65-74	16.2	64.2	19.6	17.0	63.9	19.1
75+	13.3	62.0	24.8	13.4	59.9	26.6

Model Fit: Initial Steady State

Income Distribution

	0-20%	20-40%	40-60%	60-80%	80-100%
Data	3.1	8.3	14.1	22.6	52.0
Model	1.46	5.99	13.08	24.34	55.13

Age Distribution

	20-40	40-60	60-80	80-100
Data	0.36	0.34	0.25	0.05
Model	0.23	0.49	0.20	0.08

Transitions

- COVID-19, unexpected shock, hits in the first transition period (2020).
- Partial equilibrium analysis (interest rate, wage, tax, accidental bequests, held fixed)
- Lockdown measure in 2020 (independent of infections):

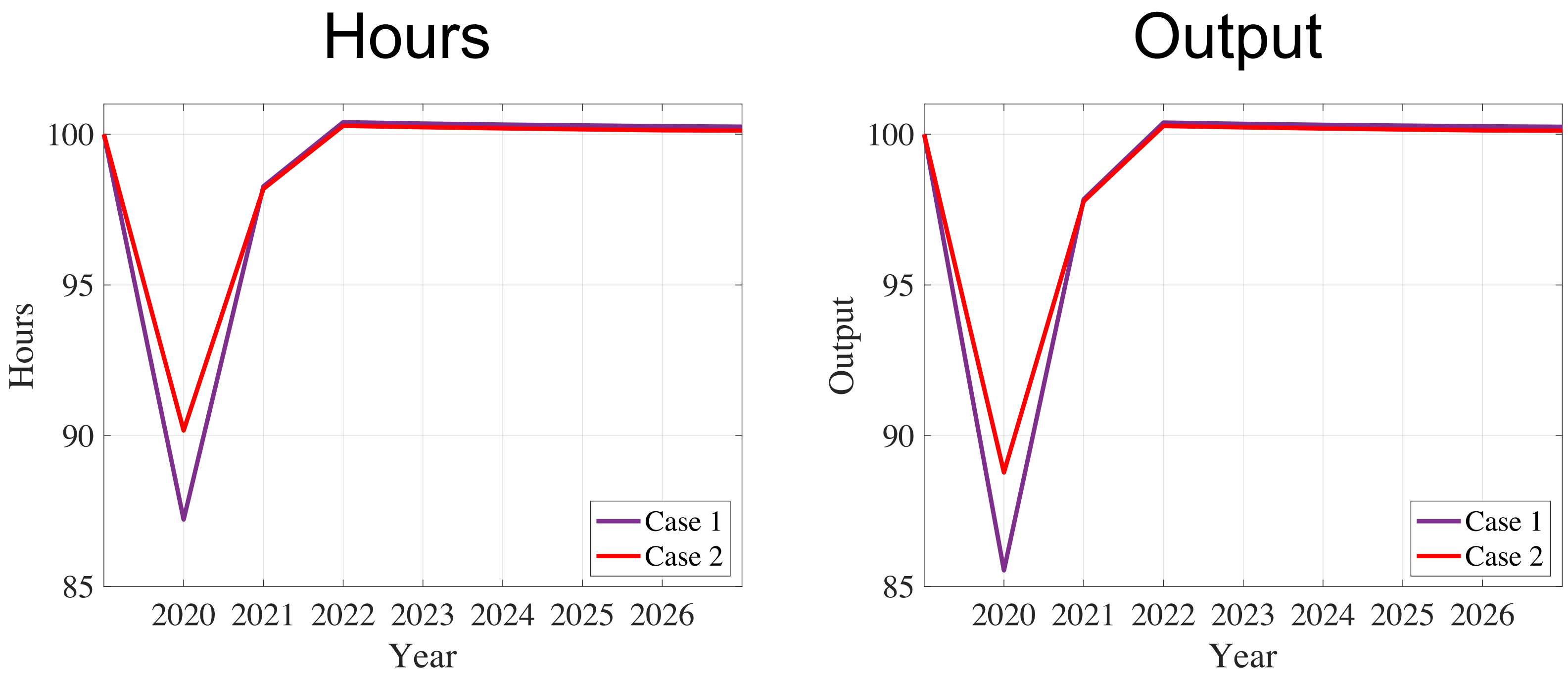
  Case 1: 11.4% of working age individuals (un-targeted) ordered to stay home

  Case 2: 11.4% of the working age individuals (targeted) ordered to stay home
    - individuals ages 40 to 64 in the *poor* health state and those 60-64 in *fair* health states
- No lockdown in 2021:
  - infection risk continues
  - self mitigation possible through labor market activity
    - reduce infection risk by 35% by not working

Question:

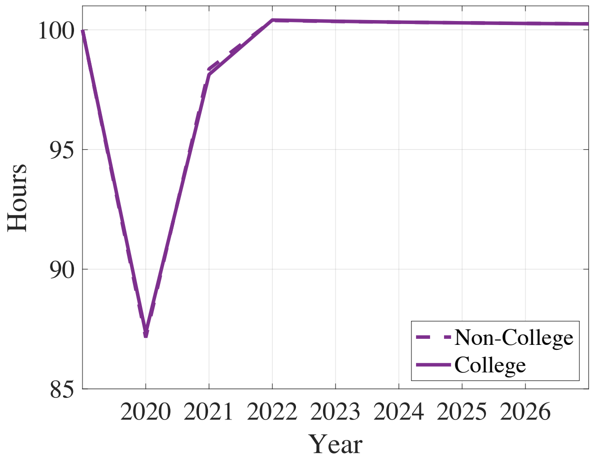
- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

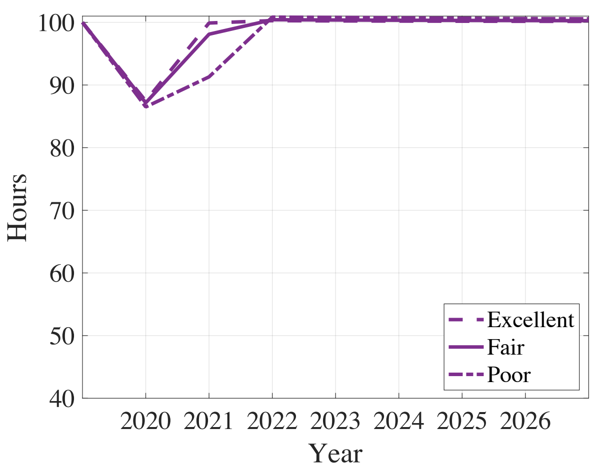
Targeted Lockdown



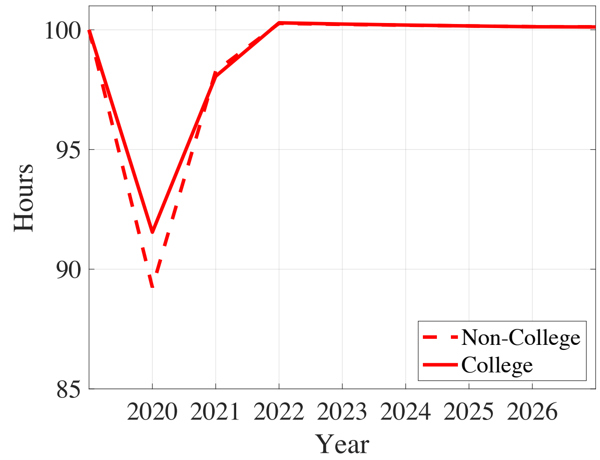
Targeted Lockdown: Hours

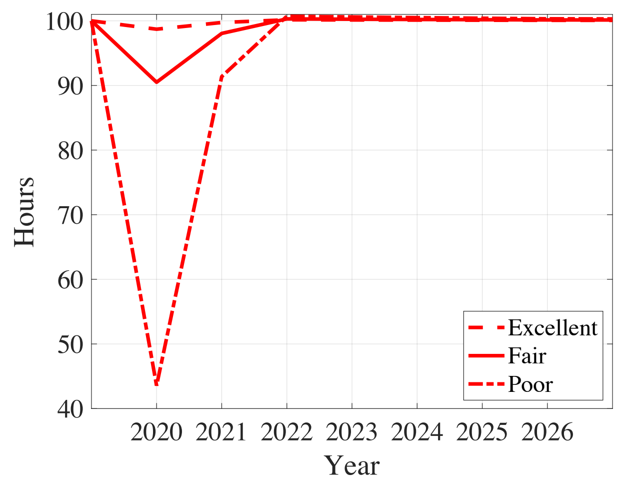
Random Quarantine





Age-Health based Quarantine





Questions:

- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

  lockdown based on health: 22.5% lesser decline in output.

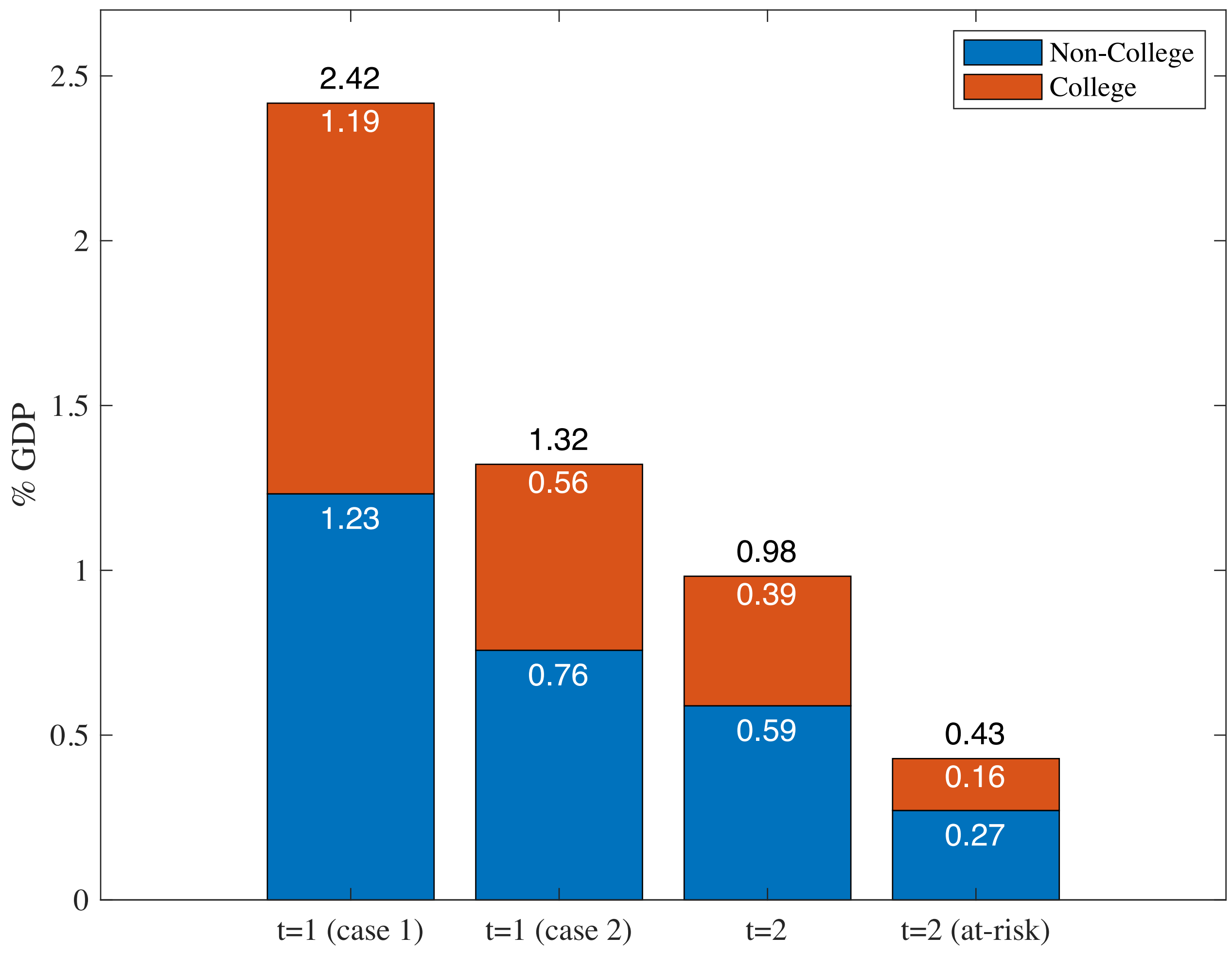
Questions:

- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

  lockdown based on health: 22.5% lesser decline in output.

- How much would it cost to convince individuals to self-isolate?

Results: Transfers



Questions:

- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

  lockdown based on health: 22.5% lesser decline in output.

- How much would it cost to convince individuals to self-isolate?

  depends on the subgroup, health basis: 1.3% GDP (2020) and 0.4% GDP (2021)

Questions:

- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

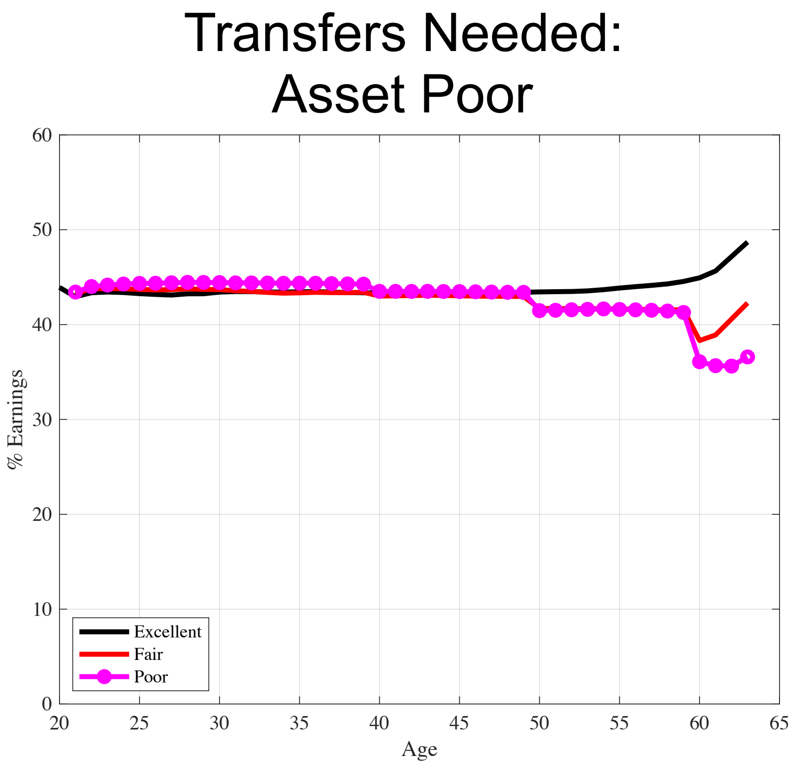
  lockdown based on health: 22.5% lesser decline in output.

- How much would it cost to convince individuals to self-isolate?

  depends on the subgroup, health basis: 1.3% GDP (2020) and 0.4% GDP (2021)

- Do transfers vary age, education, wealth, health states etc?

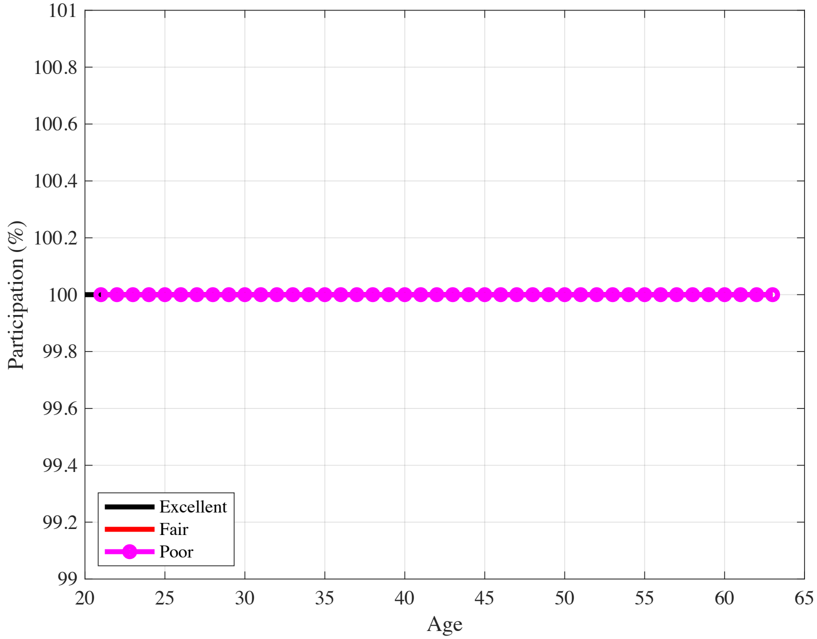
Results: Transfers and Labor Supply



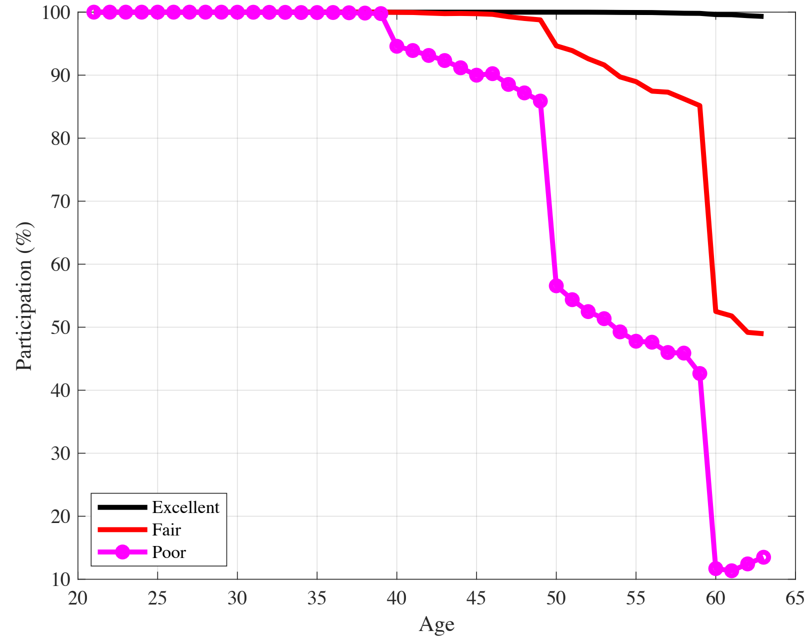
- Asset poor: bottom 20% of wealth distribution
- Asset rich: top 80% of wealth distribution

Results: Transfers and Labor Supply

Labor Supply: Asset Poor



Labor Supply: Asset Rich



- Asset poor: bottom 20% of wealth distribution
- Asset rich: top 80% of wealth distribution

Questions:

- For a given infection and lockdown scenario: what are the benefits of a targeted lockdown?

  lockdown based on health: 22.5% lesser decline in output.

- How much would it cost to convince individuals to self-isolate?

  depends on the subgroup, health basis: 1.3% GDP (2020) and 0.4% GDP (2021)

- Do transfers vary age, education, wealth, health states etc?

  Sixty year olds in worst health states, top 80 percent of wealth distribution require only 10% of their earnings

Outline

- Motivation and background
- Model
- Data & Calibration
- Results
- Robustness Checks
- Conclusions

Robustness Checks

	Benefit of health based lockdown (%)	Decline output (%)	Transfers % GDP	
	t=1	t=2	t=1	t=2*
Benchmark	22.5	2.16	1.32	0.43
Model/policy specifications				
General Equilibrium (GE)	22.8	1.93	1.41	0.44
Lockdown Rate I	32.9	2.23	0.66	0.30
Lockdown Rate II in GE	32.9	1.94	0.61	0.21
Epidemiological parameters				
Workplace Infection Risk I	22.2	2.77	1.32	0.33
Total Deaths	21.5	2.23	1.30	0.33
Workplace Infection Risk II	21.2	2.83	1.31	0.25
Fatality Rate	26.6	2.34	1.39	0.65
Second Period Infections	22.5	4.55	1.33	0.26
Lockdown Infection Risk	22.6	2.09	1.32	0.44
Economic parameters				
Value of Statistical Life	22.3	3.52	1.33	0.27
Utility Weight on Leisure	18.7	1.95	1.67	0.55

Conclusions

- Stay-at-home orders based on health could reduce the economic severity of a pandemic akin to COVID-19 by *22.5%*
- After mandatory lockdowns are lifted, output may still remain 1.93% to 4.55% below trend, in the second period, due to lingering risk of infections
- Older, wealth rich individuals self-isolate to mitigate the infection risk, while wealth poor individuals require transfers equaling 35 to 50% of their labor earnings.

Conclusions

- Stay-at-home orders based on health could reduce the economic severity of a pandemic akin to COVID-19 by *22.5%*
- After mandatory lockdowns are lifted, output may still remain 1.93% to 4.55% below trend, in the second period, due to lingering risk of infections
- Older, wealth rich individuals self-isolate to mitigate the infection risk, while wealth poor individuals require transfers equaling 35 to 50% of their labor earnings.