



Macroeconomic consequences of stay-at-home policies during the COVID-19 pandemic[☆]

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ARTICLE INFO

Keywords:

COVID-19
Mitigation
OLG
Redistribution
Welfare

ABSTRACT

Risks related to the coronavirus infection differ significantly across the age and the health status of individuals which suggest lockdowns targeting the unhealthy could reduce the fatalities due to the pandemic. In addition, labor productivities differ significantly across these groups, which suggest the economic consequences of targeted lockdowns could be quite different. Using an overlapping generations model with rich heterogeneity, we show that a targeted lockdown policy based on preexisting health status would have reduced the economic severity of the pandemic by 43% compared to a random lockdown. A simple system where government transfers are paid to those who stay home, financed by lump-sum taxes, could have achieved results similar to this health based lockdown.

1. Introduction

COVID-19 revealed how unprepared the world economies were in dealing with a pandemic. Governments implemented various different ways to stop the spread of the virus with severe economic consequences. In the U.S., 2020 ended with a 3.5% decline in GDP, an average unemployment rate of 8% and almost 3 million fewer people in the labor force. Meanwhile, the government assistance during the pandemic resulted in about a 10-percentage point increase in the government deficit.

Given the heterogeneity in the risk of infection and the progression of the disease by different age and health groups, researchers have been studying the impact of alternative lockdown policies. For example, [Acemoglu et al. \(2020\)](#), [Glover et al. \(2020\)](#), [Gollier \(2020\)](#), [Favero et al. \(2020\)](#), and [Rampini \(2020\)](#) provide extensions of the SIR model that include heterogeneity by age, sector, and/or health status. Most of these papers are concerned about the endogenous dynamics of infections and find support for targeted policies in opening up the economy. However, they usually do not incorporate the substantial heterogeneity in labor productivities where, for example, a healthy 60-year old college graduate earns roughly two times more than a unhealthy 60-year old without a college degree.¹

In this paper, we use an overlapping generations model with rich heterogeneity with respect to age, education, labor income, and health status and compare the economic consequences of a random versus a health based lockdown policy. We find that the health-based lockdown would have reduced the economic severity of the pandemic by 43%, compared to the random lockdown. We then show that a simple tax and transfer system where government transfers are paid to those who stay home could have achieved results similar to the health based lockdown. We take into account the taxation costs and the potential misrepresentation by some

[☆] We would like to thank Andrew Atkeson, Tom Chang, Ellen McGrattan, José-Víctor Ríos-Rull, Larry Harris, and the participants of Economics of Health and Aging Workshop at USC for helpful comments.

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¹ For example, [Acemoglu et al. \(2020\)](#) and [Gollier \(2020\)](#) have only three age groups and [Glover et al. \(2020\)](#) has two. An exception is [Hur \(2020\)](#) who incorporates many of these features, except for productivity differences by health.

workers and calculate the welfare gains from this system. The cost of implementing optimal transfers turns out to be small (0.05% of GDP) mostly because individuals with poor health, but relatively high assets, are willing to stop participating in the labor market to reduce their risk of infections anyway.

We model COVID-19 as an unexpected health shock that infects a large fraction of the population and changes their survival probabilities. The government's response to the pandemic includes efforts to quarantine parts of the population. In the benchmark, the lockdown policy is modeled as a random lockdown (Case 1) of a certain fraction of the population that includes the healthy and highly productive members of the workforce. Individuals are allowed to leave the labor force as a way to self-mitigate the risk of infection, which results in endogenous infection rates.² The global infection risk in the model in 2020 is calibrated such that the resulting number of infections and the death rate, which are endogenous and depend on both the extent of self-mitigation and public mandated lockdown rates, match the U.S experience. These risks continue in 2021 with infections resulting in 9.3 deaths per 10,000 individuals.³ In the benchmark economy, output decline is calibrated to 3.5% in 2020. Roughly, 44% of this decline comes from people leaving the labor force voluntarily and 56% from a mandatory lockdown that is implemented randomly on the working age population. Next, we compare the economic consequences in this economy, to one where the lockdowns are targeted towards those with underlying health conditions (Case 2). In this case, 2% of working-age individuals are quarantined based on their preexisting health status. Specifically, stay-at-home restrictions are imposed on all individuals ages 58–64 in poor health based on self-reported health status.⁴ Our benchmark results indicate that a targeted lockdown policy based on preexisting health conditions would have reduced the economic severity of the pandemic by 43% relative to a random lockdown policy.⁵ These differences arise because random lockdowns affect a large fraction of healthy and highly productive members whereas a health based lockdown affects those with lower wages due to their age/health status. Note that in the comparison between the two lockdown policies, the same number of working age individuals are ordered to stay at home and individuals in both cases face the same global infection risk. However, realized infection and death rates (which are endogenous in the model) vary due to the difference the total number and characteristics of individuals choosing/ordered to stay at home. For instance, even though the level of infections are slightly higher under the health based lockdown, the overall death rates are somewhat smaller as a larger fraction of the vulnerable working age population stays at home, as compared to the random lockdown.⁶ Thus, we conclude that, a health-based targeted lockdown would have reduced the economic severity of the pandemic compared to the random lockdown, without necessarily compromising health outcomes. However, it is not clear how such a targeted lockdown might be achieved. Next, we examine if the government could provide incentives for individuals to self-select into the quarantine via a tax and transfer scheme. We find transfers equaling 5% of one's pre-COVID-19 earnings to maximize welfare. With these transfers, the government is able to convince 5.06% of the population to stay home. Output in this case declines by 2.02%. These findings are close to the targeted lockdown based on age and health where output declines 2.01% with 4.85% of the population staying home. With optimal transfers of 5%, the asset rich individuals reduce their participation significantly, almost an 80% decline by the lowest health group and a 35% by those in fair health at age 60. On the other hand, the asset poor individuals, regardless of their health status choose 100% participation at all ages. The poorest of individuals choose to work up to transfers equaling 40% of their pre-COVID-19 earnings. As transfers increase over 5% of the pre-COVID-19 earnings, those in good health also start choosing to stay home. This response in the model is governed by a combination of low labor productivity and leisure compensation from non-work for individuals with different wealth levels. At 30% transfers, output declines reach 20% as a result of many healthy but relatively rich individuals also choosing to stay home.

Since the infection risk is not eliminated in 2021, some of the working age individuals with preexisting health conditions continue to self-mitigate by not participating in the labor force even in the absence of government transfers. This results in total hours and output in the second period to be below their pre-pandemic trends roughly by 3.5% and 1.1% respectively. Similar to the results in 2020, those who reduce their labor force participation are mainly older and wealthy individuals with preexisting health conditions. We interpret the findings from our experiments as useful for thinking about ways to mitigate future variants of the coronavirus, for understanding the labor supply choices of different types of agents and providing information regarding policy making during pandemics.

2. The model

The benchmark pre-pandemic model economy starts with an initial steady state populated by J overlapping generations that are characterized by a cohort growth rate n . Individuals face health shocks, mortality risk, individual income risk, and borrowing

² In practice, people may take many measures to mitigate the risk of infection, such as wearing masks, hand washing, social distancing, working from home etc. Here we focus on one of these activities, participating in the labor market and its consequences on the economy.

³ This is based on a projected number of 30,5491 deaths in 2021 and a population size of 328.2 million.

⁴ According to CDC, older adults and people with serious underlying medical conditions might be at a higher risk for severe illness from COVID-19. The list of these medical conditions includes those with chronic lung disease or moderate to severe asthma, people with serious heart conditions, people who are immunocompromised, and people with severe obesity, diabetes, or chronic kidney or liver disease. The percent of the population suffering from these disease ranges from 6.7% for serious heart conditions to 14% for chronic kidney or liver disease. Of course, often several chronic conditions appear concurrently and are found to be strongly correlated with the self-reported health status that is used in this paper (see for instance Miller and Bairoliya (2018), Miller et al. (2019)).

⁵ The benefits of a health based lockdown ranges between 26 to 52% under numerous robustness exercises.

⁶ Even though our model endogenously generates interesting differences in infection and death rates, a limitation of our framework is the lack of a detailed epidemiological model such as the ones used in Alvarez et al. (2020), Berger et al. (2020), Bethune and Korinek (2020), Bodenstein et al. (2020), Chari et al. (2020), Eichenbaum et al. (2020), Farboodi et al. (2020), Garriga et al. (2020), Hornstein (2020), Fernández-Villaverde and Jones (2020), Kaplan et al. (2020), Azzimonti et al. (2020). See Hevia and Neumeyer (2020) or Alon et al. (2020) for the impact of COVID-19 in emerging economies.

constraints and enter the economy with an exogenous education type e and health status \bar{h} . Education remains fixed over the life-cycle while health status evolves stochastically. In each period, agents are endowed with a unit of time that may be devoted to leisure or to earning wages in the labor market. Labor earnings also depend on productivity, which has an age-, education- (ϵ_{je}), health-specific (ξ_h), and an idiosyncratic (η) component. The stochastic process for the labor productivity shock follows a finite-state Markov chain with stationary transitions over time and which is identical and independent across all agents. All individuals retire exogenously at age j_r and receive social security income SS_e which is a function of their education level. These benefits are financed through labor income taxes, τ_t^l . At age J , individuals die with probability one. Individuals are unable to borrow or insure against idiosyncratic health and labor productivity risk by trading private insurance contracts. They may self-insure by saving one-period risk-free bonds that earn interest rate r , but borrowing is not allowed. Assets from the deceased, Tr , are distributed evenly in a lump-sum fashion across all. In transition, a new generation of 20-year-old is born every period t , whose mass grows at rate n_t .⁷

COVID-19 is modeled as an unexpected health shock (in the form of an increased mortality risk) hitting the economy in the first transition period (2020) and lasting two years. We assume that herd immunity is attained starting $t = 3$ and there is no more infection risk. The infection risk in the first two years is assumed to be higher in the workplace as opposed to staying at home. Individuals are allowed to endogenously mitigate this risk through their labor supply decisions (working versus not working), in both periods. Consequently survival between periods one and two depend on the current age, health, education status, as well as the current labor supply decision. Note that only the extensive margin of labor supply matters for mitigating COVID-19 risk. In other words, individuals can reduce their infection risk by setting their labor supply to zero.⁸ Let ψ_{jeh} denote the age, health and education specific survival probabilities for those who are not infected by the COVID-19 virus and ψ'_{jeh} denote the same for those who are infected. Then the next period survival probability for agents in each of these groups is a weighted average of the two as follows:

$$\psi_{t,jehl} = \begin{cases} (1 - \omega_t^l)\psi_{jeh} + \omega_t^l\psi'_{jeh} & \text{if } t = 1, 2 \\ \psi_{jeh} & \text{if } t > 2 \end{cases} \quad (1)$$

Where ω_t^l is a work status specific global infection risk that agents face in both periods 1 and 2. The calibration strategy as well as the values for these are discussed below in Section 3.4. Note that given our simplifying assumption of full re-infection possibility and that COVID-19 only poses a mortality risk for individuals in the model, we do not need to keep track of the infection status of individuals.

In 2020, government imposes a mandatory lockdown ($q_t = 1$) as part of the public mitigation effort. In 2021, the public mitigation efforts are eliminated, and the economy opens up, while the infection risk remains.

There is a standard production sector, where aggregate output (Y_t) is produced by a representative firm using the technology $Y_t = A_t K_t^\alpha N_t^{1-\alpha}$ where K_t and N_t are the aggregate capital stock and labor inputs (measured in efficiency units), A_t is total factor productivity, and α is the capital share.

2.1. Decision problem

An individual is characterized by their state $\tilde{z} = (a, \eta, j, e, h, q)$ and makes consumption (c), savings (a'), and labor supply (l) decisions every period. The decision problem in period t is given by:

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

subject to

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

$$y_{j,t} = \begin{cases} w_t (1 - \tau_t^l) \epsilon_{je} \xi_h \eta \ell_t & \text{if } j < j_r \text{ and } q_t = 0, \forall t \\ 0 & \text{if } j < j_r \text{ and } q_t = 1, t = 1 \\ SS_{e,t} & \text{if } j \geq j_r \quad \forall q_t, \forall t \end{cases} \quad (2)$$

$$a'_t \geq 0, c_t \geq 0, 0 \leq l_t \leq 1.$$

where the survival function $\Psi_{t,jehl}$ is as described in Eq. (1), value function $V(\cdot)$ is the expected discounted lifetime utility with a given state vector and $\Phi_t(\eta, h)$ represents the joint probability distribution over health and labor productivity states. The first line of Eq. (2) describes the full income of working age individuals who are not quarantined ($q_t = 0$). Note that in period two, no one is quarantined, so by design $q_2 = 0$. It is also possible for agents to choose not to work, that is supply zero hours and receive zero income, such an action leads to lower risk of infection. Finally, those who are retired receive social security income in all states of the world. The initial steady state for this economy, before the COVID-19 shock hits, is defined in Appendix A.

⁷ The cohort-growth rate decreases over time to mimic population aging in the U.S. and converges to a lower rate \underline{n} to reflect a future “older” steady state.

⁸ To simplify the analysis, we assume that infections are completely independent between the two periods, thus allowing for reinfections to occur.

3. Calibration

3.1. Preferences and demographics

We calibrate the model such that the initial steady state matches some key moments of the U.S. economy in 2019. Individuals enter the economy at age 20 and die with probability one at age 100. The growth rate of 20-year-old individuals (n) in the initial steady state is set at 1.8% in order to match an old-age dependency ratio of 28% in 2020 (UN, 2019).⁹ Retirement is exogenous at age 65. Preferences follow a standard Cobb–Douglas utility function:

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

where risk aversion, σ , is set to 3.56, which implies an inter-temporal elasticity of substitution, $\frac{-1}{\gamma(1-\sigma)-1}$, of 0.5. The relative weight of consumption, γ , is set to 0.39 to match the average fraction of time working to a third of the time endowment. The time discount factor β is set to 0.96 to match an annual capital-output ratio of 3.0. Finally, \bar{u} is set to 10 in order to have a model implied value of statistical life of an average 20-year-old as 3 million. We report the sensitivity of our results to this parameter in the appendix as it impacts the percent of the population who is willing to self-mitigate by leaving the labor force.

3.2. Labor productivity, government, and technology

The labor productivity in the model comprises of the stochastic component η , the health specific component ξ_h , and a deterministic age- and education-specific component ϵ_{je} . The Markov chain for the stochastic component of productivity is estimated by assuming an underlying AR(1) process in logs:

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

Parameters governing the stochastic process for productivity shocks are taken from Fuster et al. (2007).¹⁰ We then use the Tauchen method to approximate this process with a Markov chain over four discrete states. Deterministic age- and education-specific labor productivity ϵ_{je} estimates are taken from Conesa et al. (2018). Finally, the health-specific component of wages, ξ_h , is set to 1 for agents in *excellent* health state. For the bottom two health states, ξ_h is set to match the ratio of earnings for agents in *good* and *excellent* health and *poor* and *excellent* health states resulting in $\xi_{good} = 0.86$ and $\xi_{poor} = 0.63$. Fixed education state takes two possible values {*college*, *non-college*} where the share of college graduates is set to 40% based on data from the U.S. Census Bureau.¹¹ The Social Security replacement rate is set to 44% following Fuster et al. (2007). The capital income share α is set to 0.36 and the depreciation rate δ equals 5.9%. Finally, the total factor productivity level A is normalized to 1.

3.3. Health and mortality

Health can take three possible values {*excellent*, *good*, *poor*} in the model. We identify these health states in the Medical Expenditure Panel Survey (MEPS) data from the self-reported health status variable.¹² Health transitions across these states are then estimated by running an ordered probit of self-reported health status on previous year health status, education, and a quadratic function of age.

Survival probabilities in the model vary with age, education and health status ψ_{jeh} . These probabilities cannot be directly derived from MEPS as it does not sample the institutionalized population. So these survival probabilities are estimated in two steps following Conesa et al. (2020). First, we estimate the raw age-, education- and health-specific profiles from the MEPS data by running an ordered probit model of death indicator on self-reported health status, age quadratic, and education as mentioned earlier. In a second step, we adjust these profiles to match both the age-specific survival probabilities in the National Vital Statistics System data and the education survival premium. Fig. 1 summarizes the survival probabilities by age, health, and education status.

3.4. COVID-19 shock

3.4.1. Infections

The overall level of COVID-19 infections and corresponding deaths are endogenous outcomes in the model which depend on both the global infection risk and individuals' behavioral response to mitigate that risk. As a result, we calibrate the global risk in the model, in both periods, such that the overall realized infections in the model, in the random quarantine case with self-mitigation, matches that of the U.S. Since the overall infection rates in the U.S. are unknown, we compute it using the total reported COVID-19

⁹ It is equal to 0.005% in the final steady state to target an old-age dependency ratio of 55%.

¹⁰ The authors use an income process which is education specific. We adjust their estimate for the average population and use $\rho = 0.83$, and $\sigma_\eta^2 = 0.022$.

¹¹ Current Population Survey, Annual Social and Economic Supplement, 2018.

¹² The Medical Expenditure Panel Survey asks respondents to self report their health on a scale of 1 to 5 where 1 is "Excellent", 2 is "Very Good", 3 is "Good", 4 is "Fair" and 5 is "Poor". For computational simplicity, the 5-point scale is converted into a 3 point scale by grouping individuals of "Very Good" and "Good" health into the good health category and those in "Fair" and "Poor" into the "poor" category.

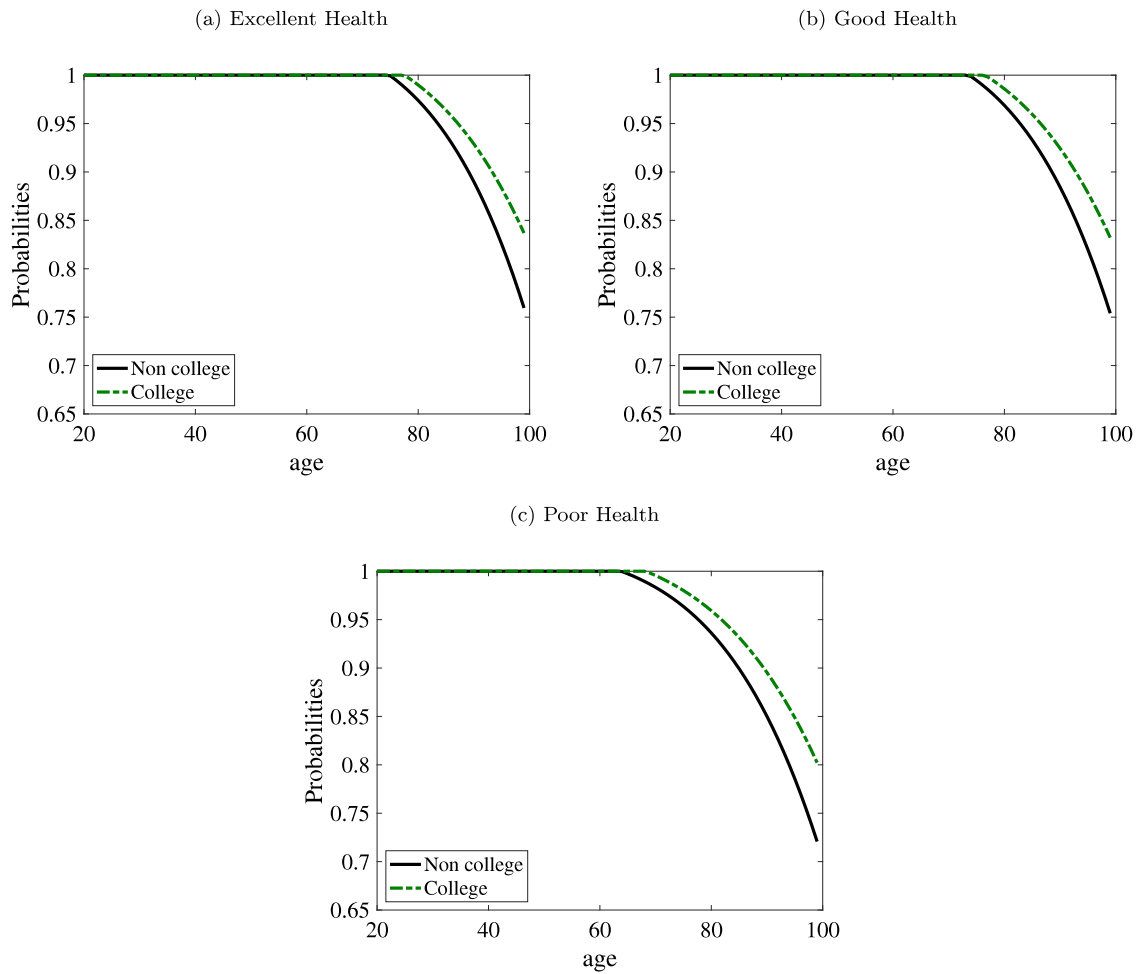


Fig. 1. Survival probability.

deaths and the estimated fatality rate. The former is set to 377,883 in 2020 following [Ahmad et al. \(2021\)](#) and 298,128 for the year 2021.¹³ For the latter, we use an estimate of 0.3%.¹⁴ The fatality rate of 0.3% along with a death rate of 0.11% (377,883 deaths in the U.S. population) implies that roughly 38% of the population were infected during 2020 and 31% in 2021. Since certain activities like being in a workplace may result in higher infection rates than staying home (see, for instance, [Baker et al. \(2020\)](#) and [Koh \(2020\)](#)), we assume a 35% higher global risk of infections while working relative to non-work. [Table 1](#) reports annual COVID-19 induced excess death rates both in the model and the data for years 2020–2021. The death rates are per 10,000 people and are computed assuming the same population size of 328.2 million in both years. A global infection risk of 39% and 31.3% in the model is able to endogenously generate infection rates which are similar to the data for the years 2020 and 2021 respectively. In other words, in the benchmark model with self mitigation and random quarantine, individuals face a global infection risk of 39% in 2020 with workers observing a 35% higher risk than non-workers. As a result of this global risk, some individuals choose to stay at home to mitigate the risk of COVID-19 induced mortality, some are quarantined and stay at home, which also reduces their risk. As a result of a combination of the policy and self induced mitigation measures, the realized infection rate in the model (38.3%) is somewhat smaller than the global risk.

Note that we assume that the global infection risk remains the same across all cases. However, the realized infections and death rates may vary due to the different sizes and characteristics of the population that stays at home. For instance, second row of [Table 1](#) shows that the infection rates are somewhat higher under Case 2. This is due to the fact that the infection rates in the model only depend on the fraction of those working in the labor market and the total labor supply in Case 2 is higher than Case 1. Unlike infection rates, death rates depend heavily on the characteristics of the population that stays at home. As a result, they are lowest

¹³ Based on 2021 projections from the Institute for Health Metrics and Evaluation.

¹⁴ The fatality rate is estimated using data from Iceland, which is known to have carried out significant random testing. A recent USC-LA County study also points to fatality rates of 0.1–0.3% ([Sood et al., 2020](#)).

Table 1
Death and infection rates model vs. data.

	Data ^a	Model	
		Case 1	Case 2
<i>Year 2020</i>			
Deaths (per 10,000)	11.51	11.60	11.56
Infections (%)	38.30	38.30	38.44
Global infection risk (ω_l)	-	0.39	0.39
Workers ($l > 0$)	-	0.42	0.42
Non-workers ($l = 0$)	-	0.28	0.28
<i>Year 2021</i>			
Deaths (per 10,000)	9.31	8.35	8.35
Infections (%)	31.0	31.0	31.0
Global infection risk (ω_l)	-	0.31	0.31
Workers ($l > 0$)	-	0.34	0.34
Non-workers ($l = 0$)	-	0.22	0.22

^adeath rates correspond to a total death count of 377,883 in 2020, 298,128 in 2021 (based on projection) and a total population of 328.2 million in the data. Case 1 refers to random quarantine and Case 2 refers to health based quarantine.

Table 2
Fatality Rate = 0.3%.

Age group	Fatality rate (%) ^a	Age-specific scale ^b
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

^aFerguson et al. (2020).

^bx differs by health state, x=0.000778 for those in *poor* health and x=0.000389. for those in *good* health states.

under Case 2 (health based quarantine) where together with self mitigation, the labor supply of those with pre-existing conditions (and who are most susceptible to COVID-19 induced mortality) is the lowest.

3.4.2. Mortality

Given the global infection risk and the fatality rate of 0.3%, we use age-specific fatality rate estimates from Ferguson et al. (2020) and scale the survival probabilities for the bottom two health groups using an age- and health-specific scale to obtain the corresponding death rates. For the health scale, those in the worst health states are assumed to be affected twice as badly as those in the middle health state. We also do not scale the COVID-19-related mortality for those who are in excellent health or below the age of 40 in the model.¹⁵ Table 2 provides these age and health specific scaling of fatality rates. Finally we use these age–health specific scales to scale the benchmark survival probabilities such that the model implied excess COVID-19 deaths in the first period equals the excess deaths in the data. Figs. 12 and 13 in the Appendix, compare the estimated survival probabilities for those who are not infected (ψ_{jeh}) with these scaled probabilities due to COVID-19 infections (ψ'_{jeh}).

3.4.3. Lockdown rate

In the benchmark model with self-mitigation, some individuals decide to leave the labor force to reduce their risk of infections and some individuals are forced to stay home due to random lockdowns. In the U.S. during 2020 about 3 million people left the labor force. While it is hard to gauge the exact reasons, in a new survey by the Bureau of Labor Statistics, which asked “whether people teleworked or worked from home because of the pandemic; whether people were unable to work because their employers closed or lost business due to the pandemic; whether they were paid for that missed work; and whether the pandemic prevented job-seeking activities”, 7.1% of those not in the labor force cited not looking for work because of the coronavirus pandemic in May 2020. By August 2021, 1.5% of those not in the labor force were still citing this reason for their decision. In addition, mandated lockdowns in the U.S. resulted in very high unemployment rates, finally 2020 ending with a 8.3% unemployment rate and a 3.5%

¹⁵ Fatality rates are very low for those below 40 and or those without any morbidities.

Table 3

Age distribution.

Source: U.S. Census Bureau, Current Population Survey, Annual Social and Economic Supplement, 2019. The columns may not to sum to 100 due to rounding.

Age share				
	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

Table 4

Health and income distribution.

Age–health distribution						
	Model			Data ^a		
	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
Share of income						
	0%–20%	20%–40%	40%–60%	60%–80%	80%–100%	
Data ^b	3.1	8.3	14.1	22.6	52.0	
Model	1.46	5.99	13.08	24.34	55.13	

Note: The Medical Expenditure Panel Survey asks respondents to self report their health on a scale of 1 to 5 where 1 is “Excellent”, 2 is “Very Good”, 3 is “Good”, 4 is “Fair” and 5 is “Poor”. This 5-point scale is converted into a 3 point scale by grouping individuals of “Very Good” and “Good” health into the “Good” health category and those in “Fair” and “Poor” into the “Poor” category.

^aData comes from Summary Health Statistics: National Health Interview Survey, 2018.

^bData comes from the U.S. Census Bureau, Current Population Survey, 2018 and 2019 Annual Social and Economic Supplements.

decline in output. In the model economy, we use the decline in output as a calibration target and examine a combination of cases with different numbers of people leaving the labor force due to self-mitigation efforts versus losing their jobs due to mandated lockdowns. We find that in our benchmark case (random quarantine), a 2% mandatory lockdown of the working age population results in a 3.5% decline in output. The total employment goes down by 6%, two-thirds of which coming from people who are self-mitigating and one-third from mandatory lockdowns. So we keep the lockdown rate to be 2% for both random and targeted lockdown cases.

4. Results

The initial steady state is calibrated to match key moments of the U.S. economy, in terms of the age distribution, health distribution, and income distribution as well as other macroeconomic targets such as the capital output ratio and average hours worked, prior to the COVID-19 shock. We use data from U.S. Census Bureau (Current Population Survey, 2018 and 2019 Annual Social and Economic Supplements) to compare the model implied earnings distribution with that in the data. The health distribution in the model is exogenous and is determined by the age–education-specific profiles estimated from the Medical Expenditure Panel Survey. As a further check, we compare the model implied health distribution with data from the National Health Interview Survey (2018). Since MEPS is a nationally representative subsample of households that participated in the prior year’s National Health Interview Survey, it has the same 5-point self-reported health measure, which we combine into three as mentioned above. [Table 3](#) summarizes the age distribution and [Table 4](#) summarizes the age distribution of health and the income distribution in the model and in the data.¹⁶

This initial steady state is shocked with COVID-19 in the first transition period and the government imposes stay-at-home orders. In the second period, the public mitigation efforts are eliminated, the economy opens up, while the infection risk remains. In the third period the infection shock disappears. In the first two periods, the infection rate is endogenous and affected by the labor supply choice of the individuals. In order to disentangle the behavioral response of the households to the shock from other general equilibrium effects, we keep the wage rate, the interest rate, taxes, Social Security benefit levels, and accidental bequests fixed at baseline transition levels. We also In all experiments, all variables are normalized by their baseline levels to reflect the changes under each experiment relative to baseline transitions without COVID-19.

¹⁶ Income data is from the U.S. Census Bureau, Current Population Survey, 2018 and 2019 Annual Social and Economic Supplements, and health data is from National Health Interview Survey, 2018.

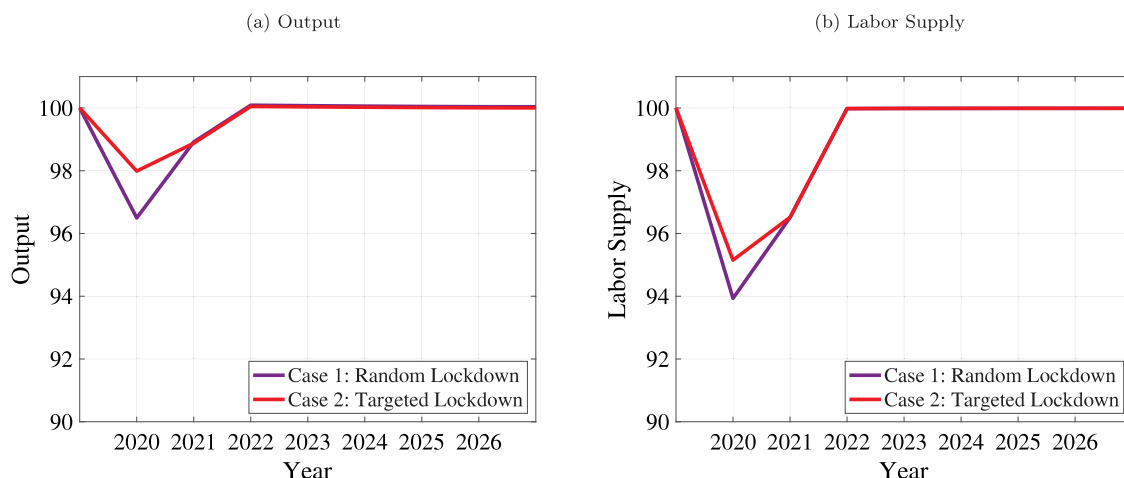


Fig. 2. Different mitigation methods.

Note: Changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). In 2021, lockdown is lifted while the infection risk remains.

4.1. Random versus targeted stay-at-home policies

We start by examining the impact of the two different stay-at-home policies in the first period on output and labor supply. In the first case, the lockdown is implemented by randomly quarantining a fraction of the working-age population. In the second case, working-age individuals are quarantined based on their health status. Those experiencing stay-at-home orders face a lower risk of infections and a lower mortality rate. Also, individuals are allowed to self-mitigate the infection risk through their labor supply behavior. Our calibration uses the COVID-19 data for the U.S. economy in 2020 and projections for 2021, keeping the global infection risk the same across the two cases. Infection and death rates, however, are endogenous outcomes in the model and vary across experiments due to the difference in the total number and characteristics of individuals choosing/ordered to stay at home. In the first case, the lockdown is implemented by randomly quarantining 2% of the working-age population. In the second case, lockdown is imposed on all individuals ages 58–64 in the poor health state (making up 2% of the working-age population).

Fig. 2 summarizes the changes in output and labor supply (fraction of the population with positive hours of work) under both stay-at-home policies, Case 1-random and Case 2-targeted. In both cases, older and unhealthy individuals, who experience the highest mortality risk due to COVID-19 infections, chose not to work in order to self-mitigate the infection risk. This results in a 4.15% decline in the labor supply and 1.53% decline in output. When a random lockdown is imposed (Case 1), another 2% of the workforce is forced to stay home and output declines by 3.5%. In case of a targeted lockdown where again 2% of the individuals are ordered to stay home, total labor supply declines by 4.85% and output declines by 2.01%. Quarantining the unhealthy and older individuals with low labor productivity, hurts economic output substantially lesser (2.01% as opposed to 3.5%). The targeted lockdown case has the largest overlap with the population willing to self mitigate. As a result, the additional decline in output due to lockdowns is much smaller. This is not the case under the random lockdown case where young and healthy individuals are chosen at large to stay at home, in addition to those already staying at home due to self mitigation efforts. Consequently, the largest economic declines take place under Case 1 with a random quarantine. While infection rates vary somewhat across the different experiments and are slightly higher under the targeted case, the total fatalities are smaller compared to the random case. This is due to the fact that infections only depend on the total number of people in the workforce which is higher under the targeted case. The associated fatalities however depend on the age and health composition of individuals and the targeted case has the lowest number of these vulnerable individuals working.

These results show our main finding, that a health and age based lockdown would have resulted in a 43% smaller decline in output compared to the random lockdown scenario. We examine the sensitivity of this result to several modeling assumptions and parameter choices in Appendix. For example, if the fraction of the population who self-mitigate by exiting the labor force is zero in the benchmark, the economic benefit of a targeted lock down goes up. We find that a targeted case now results in a 52% smaller decline in output compared to the random case.¹⁷

In 2021, lockdown is lifted while infection risk remains. The decline in output and labor supply in the second period depend solely on individuals' responses to the lingering infection risk. Young agents, regardless of their health status, and old individuals with excellent health choose to go back to work fully, while younger and older individuals in poor health choose to reduce their labor market activity. Overall, relative to their pre-pandemic levels, labor supply declines by 3.5% and output declines by 1.1%.

¹⁷ We re-calibrate the fraction of people subject to mandatory lockdown to obtain the same 3.5% drop in output in the random quarantine case. Refer to Appendix B.1 for more details.

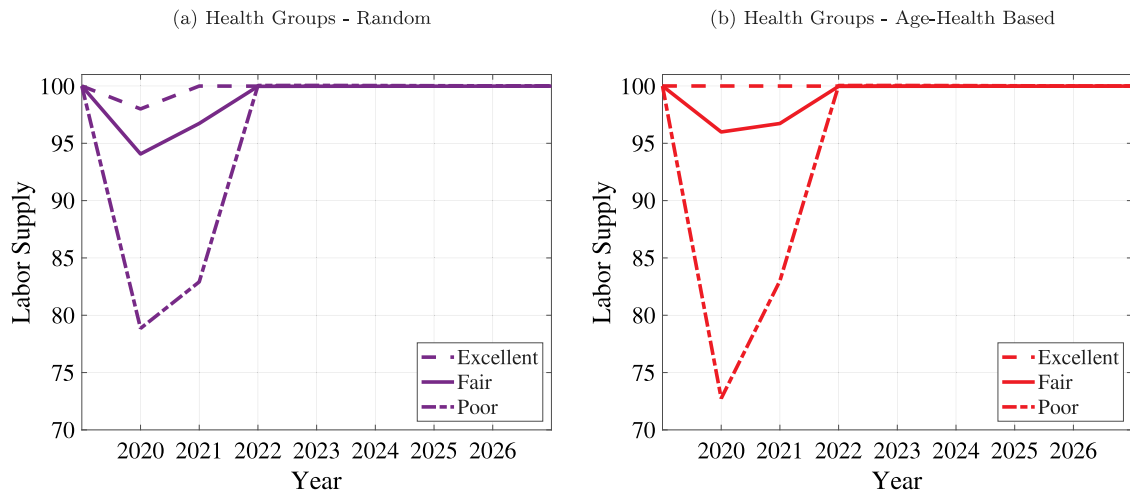


Fig. 3. Different mitigation methods: labor supply by health groups.

Note: Panels a, and b display the changes in labor supply (relative to baseline) for different health conditions under the two different mitigation scenarios.

To further examine the responses of different individuals to the aggregate infection risk, we display the changes in labor supply based on preexisting health conditions under the two lockdown policies in Fig. 3. Under the random lockdown case, roughly 21% of those in poor health, 6% of those in fair health, and 2% of those in excellent health end up staying at home. Some of these declines are due to the self-mitigation efforts of those in poor health. In particular, 19.5% of those in poor health choose to leave the labor force voluntarily in both lockdown cases. While there is little additional decline in labor supply for this group under random lockdown case, the targeted case brings down their labor supply further resulting in a total 27.3% decline compared to the baseline. Targeted public mitigation result in no change in the labor supply of those in excellent health as they do not face any COVID-induced mortality risk. However, the random lockdown case results in a 2% decline in the labor supply of this group, as compared to baseline.

4.2. Implementing targeted lockdown

The exercise conducted above indicates that a targeted lockdown, in terms of health and age, achieves a better balance between protecting the vulnerable and mitigating output losses due to reduction in economic activity compared to a random lockdown. However, it is not clear how such a lockdown might be achieved. In order to address this issue, we ask the following questions: Can the targeted lockdown be achieved through a system of tax-transfers? What are the welfare implications of such a fiscal program? How much will it cost? In order to answer these questions, the government offers transfers (as a percent of the individual's pre-COVID-19 steady state earnings) for those of working age population who voluntarily choose to stay at home. We search for the optimal level of transfers that are financed through lump-sum taxes paid by all agents in the economy.¹⁸

Panel (a) in Fig. 4 shows the aggregate welfare (consumption equivalent variation measure) as the level of fiscal transfers are increased. We find that transfers equaling 5% results in the maximum welfare gains, albeit extremely small ($CEV \approx 0.0002\%$). At transfers over 5%, aggregate welfare changes remains negative but small. For instance, with transfers as large as 25% of previous own earnings, the aggregate welfare change is only -0.02% . In other words, agents in this period are willing to give up roughly 0.02% of their period $t = 1$ consumption, in every state of the world, to live in the endogenous mitigation world without such a government intervention (or with zero transfers). However, the aggregate welfare changes mask the heterogeneity across different age groups as shown in panel (b) of Fig. 4. As expected, we find the welfare gains to be highest among the older workers experiencing higher mortality risk due to COVID-19 infections. In fact, the welfare change jumps discretely at ages 40, 50 and 60 when the excess mortality risk due to COVID-19 jumps four times between 40 and 50 and roughly 15 times at age 60.¹⁹ At higher levels of transfers, the welfare change remains positive for the oldest of the workers, however, all other workers experience negative welfare due to the increase in corresponding taxes.

We find that, the cost of providing the welfare maximizing level of transfers (5%) is 0.05% of GDP. The reason they are relatively small is due to the fact that it takes very little to convince many of the unhealthy individuals to stay home. Indeed, many of the unhealthy but asset rich individuals would stay home even with no transfers. These properties are explained in detail in Section 4.2.1.

¹⁸ Note that financing these transfers through labor income taxes could be problematic for our analysis. This could give an additional perverse incentive to individuals in otherwise good health, but with low labor market productivity, to stay at home in order avoid paying these taxes in the first period.

¹⁹ Those above age 65 all experience welfare losses since they do not receive any transfers but have to pay the lump-sum taxes. However, these losses are extremely small and indistinguishable from zero.

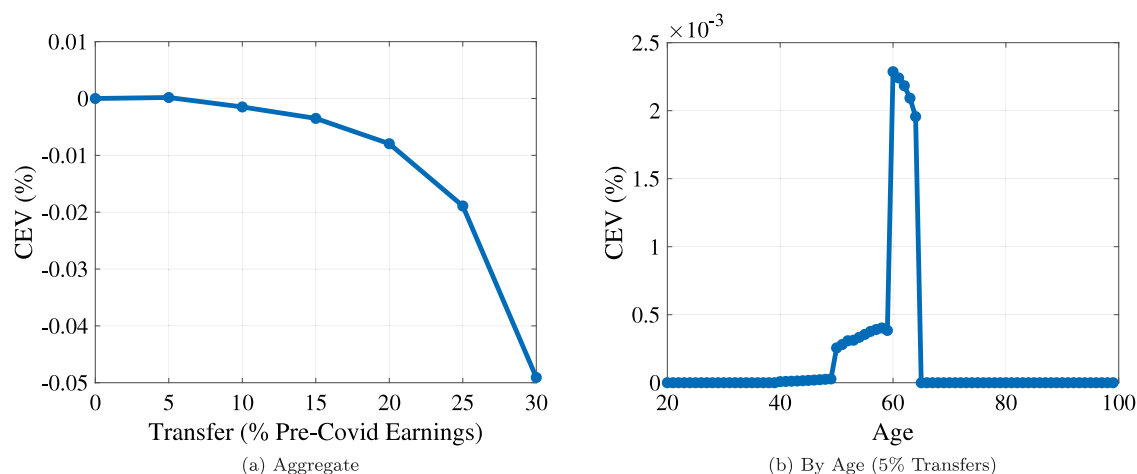


Fig. 4. Consumption equivalent welfare.

Note: Consumption equivalent variation measure of welfare is reported for the endogenous mitigation case with varying levels of transfers. Transfers are as percent of one's own pre-COVID-19 steady state earnings and financed by lump-sum taxes paid by all.

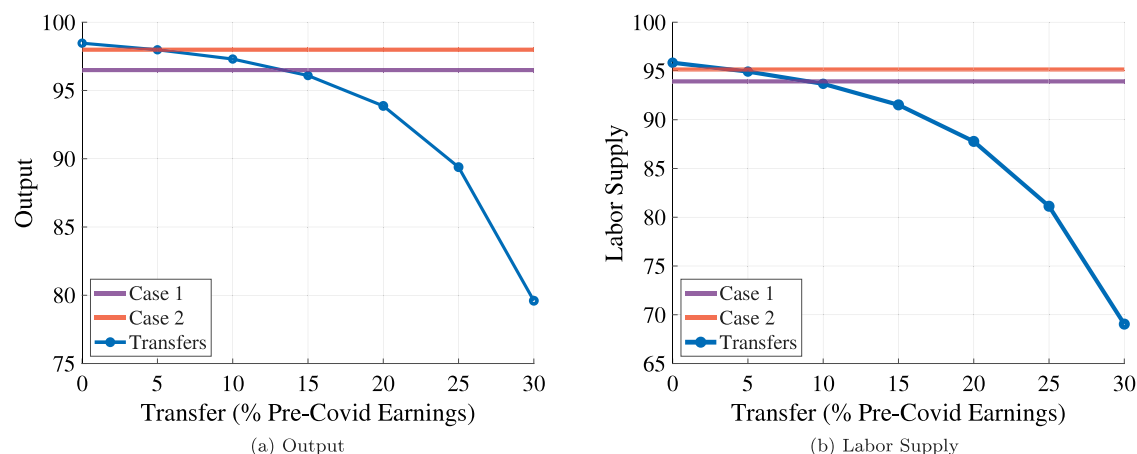


Fig. 5. Output and labor supply under different tax and transfers schemes.

Note: changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). Transfers refer to the scenario without mandatory lockdowns but individuals are given a percent of one's own pre-COVID-19 steady state earnings for staying at home. These are financed by lump-sum taxes paid by all.

Fig. 5 shows the output and labor supply ratios for the year 2020 for a number of scenarios.²⁰ Case 1 and Case 2 still refer to the aggregate output for the random and targeted lockdown scenarios respectively. *Transfers* refers to a scenario without mandatory lockdowns, only allowing individuals to self mitigate the infection risk as discussed above. Each point along the horizontal axis in this case refers to a different transfer amount, distinguished by percent of one's own pre-COVID-19 earnings that are given for staying at home in the year 2020. Note that as the transfers go up, the labor supply and output both decline as more and more individuals choose the stay-at-home option over working in the labor market. Under optimal transfers, 5.06% of the population stays home and output declines by 2.02%. These findings are close to the targeted lockdown based on age and health where output and labor decline are 2.01% and 4.85% respectively and lower than the random lockdown with the 3.5% decline in output and 6.15% decline in labor.

²⁰ Output and labor supply changes relative to the transition path without COVID-19 are reported.

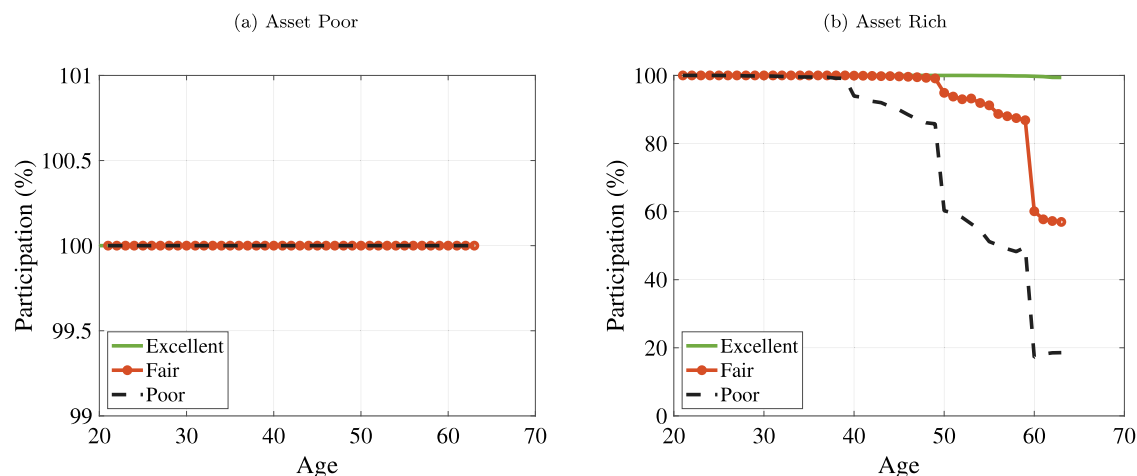


Fig. 6. Labor supply: optimal transfers (5% of earnings).

Note: labor supply behavior of the asset rich (top 80 percentile) and asset poor (bottom 20 percentile) groups in different health states is shown for the year 2020. Results are reported for the optimal transfer case.

4.2.1. Individual characteristics

Next, we examine the characteristics of individuals who choose the stay-at-home option at varying levels of transfers. Panels (a) and (b) in Fig. 6 show the labor supply behavior of the asset poor (bottom 20 percentile) and asset rich (top 80 percentile) groups in different health states, in the case with the welfare maximizing level of transfers of 5%. We find that, only asset rich individuals, in less than perfect health, who are not dependent on their labor earnings for financing current period consumption, reduce their labor supply. There is an almost 80% decline by the lowest health group and a 40% by those in fair health at age 60, when the mortality risk due to infections is 15 times higher than at age 40. In fact, roughly 20% of the working age population in the lowest health group would choose to stay home even with zero transfers. Asset poor individuals, however, (panel a of Fig. 6) work the same as before, regardless of their health status with 100% participation at all ages.

It is possible, however, that high enough transfers might incentivize some individuals in excellent health conditions to choose the stay-at-home option as well. This response in the model is governed by a combination of low labor productivity and leisure compensation from non-work for individuals with different wealth levels. Given that such individuals are not the intended recipients of a health based lockdown, we check the extent to which this response exists in different levels of transfers. For the optimal level of transfers, none of those in excellent health choose the stay at home option. However, this is not the case at higher levels of transfers. Fig. 7 shows the labor supply behavior for the three health groups for varying levels of transfers. With transfers higher than 10%, younger individuals, or those in excellent health, start choosing the stay-at-home option as well. They are mostly individuals with low labor productivity. At the highest transfers (30%) considered here, a large fraction of those even in excellent health choose the stay-at-home option.

4.2.2. Need-based transfers

Our findings so far indicate that while the tax-transfer program can help implement the targeted lockdown scenario in a welfare neutral way, the response will mostly be coming from health poor albeit relatively wealth rich individuals. We next explore the possibility of making these transfers need-based. Specifically, in the next set of experiments, we only offer stay-at-home transfers to wealth poor individuals (those in the bottom 20 percentile of the wealth distribution).²¹ Fig. 14 in the Appendix shows the 2020 output decline and labor supply changes under different need-based transfer levels. These results are also compared with random and targeted lockdown cases like earlier. First of all, note that due to reasons discussed above, there is no change in aggregate output or labor supply with transfers even as high as 30% of own earnings. However, with transfers equaling 40% and higher, there is a large uptick in people choosing stay-at-home options resulting in significant declines in output. For instance, for transfers equaling 40 and 50%, output declines by 6.5 and 15% respectively. There is no further change with higher transfers as all those who qualify for these transfers have chosen this option at 50% transfer levels. This highlights the fact that due to their low value of statistical life, it is difficult to incentivize unhealthy and wealth poor individuals to stay at home using a simple need-based transfer scheme as discussed here. Any efforts to incentivize the poor health individuals in this group will also result in those with low wealth but excellent health (without any excess mortality risk due to COVID-19 infections) choosing these transfers over working in the labor market.

²¹ Note that the corresponding lump-sum taxes are still paid by all and self-mitigation with zero transfers is an option available to all agents.

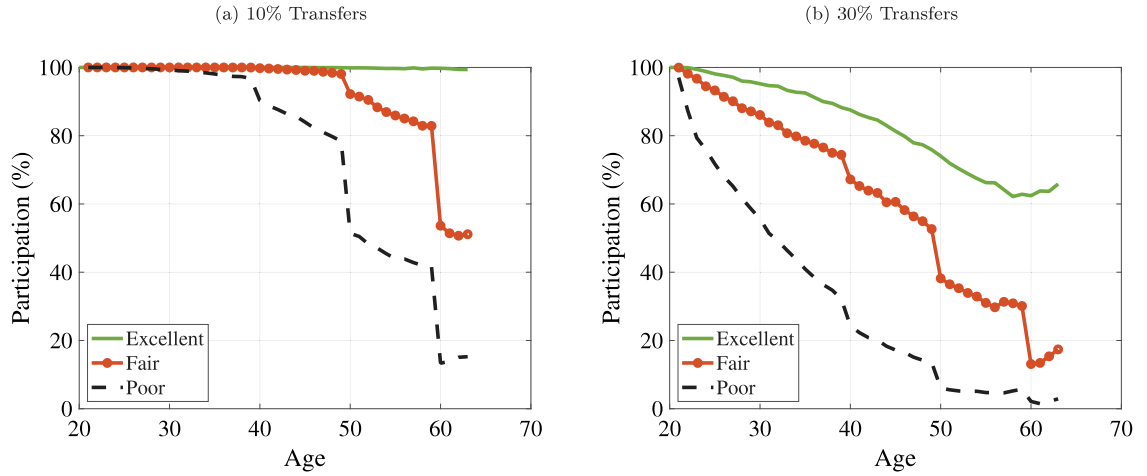


Fig. 7. Aggregate labor supply by transfer levels.

5. Conclusions

In this paper, we evaluate the economic consequences of two different lockdown policies to slow the spread of infections due to the COVID-19 pandemic. We use an overlapping generations model with rich heterogeneity with respect to age, education, labor income, and health status. Our findings indicate that, a health-based targeted lockdown would have reduced the economic severity of the pandemic by 43%, compared to the random lockdown. We show that the government could provide incentives for individuals to self-select into the quarantine via a tax and transfer scheme that almost mimics results of the targeted lockdown. Overall, transfers equaling 5% of one's pre-COVID-19 earnings maximize welfare where 5.06% of the working age population chooses to stay home. The fiscal cost of these transfers are fairly small, mostly because asset rich but unhealthy individuals require very little or nothing to stay home to lower their risk of being infected. Output in this case declines by 2.02% as opposed to 3.5% under the random lockdown case.

Data availability

Data will be made available on request.

Appendix A. Baseline stationary equilibrium

Let $a \in \mathbb{R}_+$, $\eta \in \mathcal{E} = \{\eta_1, \eta_2, \dots, \eta_n\}$, $j \in \mathcal{J} = \{1, 2, \dots, J\}$, $e \in \mathcal{E}_d = \{e_1, e_2, \dots, e_n\}$, $h \in \mathcal{H} = \{h_1, h_2, \dots, h_n\}$ and $\mathcal{R} = \mathbb{R}_+ \times \mathcal{E} \times \mathcal{J} \times \mathcal{E}_d \times \mathcal{H}$. Let $B(\mathbb{R}_+)$ be the Borel σ -algebra of \mathbb{R}_+ and $P(\mathcal{E}), P(\mathcal{J}), P(\mathcal{E}_d), P(\mathcal{H})$ the power sets of $\mathcal{E}, \mathcal{J}, \mathcal{E}_d, \mathcal{H}$, respectively. Let $\Sigma_{\mathcal{R}} \equiv B(\mathbb{R}_+) \times P(\mathcal{E}) \times P(\mathcal{J}) \times P(\mathcal{E}_d) \times P(\mathcal{H})$. Let \mathcal{M} be the set of all finite measures over the measurable space $(\mathcal{R}, \Sigma_{\mathcal{R}})$. Let $Q_{je}^h(h, H) = \text{Prob}(h' \in H \mid h, j, e)$, $Q^\eta(\eta, \mathcal{E}) = \text{Prob}(\eta' \in \mathcal{E} \mid \eta)$, $\forall t$. Let $\Pi^e(\mathcal{E}_d)$ denote the invariant probability measure over education types of an incoming generation. Let $\Pi^\eta(\mathcal{E})$ denote the time invariant probability measure associated with Q^η . Given a sequence of pension replacement rates $\{b_t\}_{t=1}^\infty$, and initial conditions K_1 and Φ_1 , a competitive equilibrium is a sequence of functions for individuals $\{v_t, c_t, a'_t, l_t\}_{t=1}^\infty$, production plans for firms $\{N_t, K_t\}_{t=1}^\infty$, prices $\{r_t, w_t\}_{t=1}^\infty$, tax rates $\{\tau_t^l\}_{t=1}^\infty$, Social Security benefits $\{SS_{e,t}\}_{t=1}^\infty$, transfers $\{Tr_t\}_{t=1}^\infty$, and measures $\{\Phi_t\}_{t=1}^\infty$, $\Phi_t \in \mathcal{M}$ such that:

1. Given prices, tax rates, Social Security benefits, transfer rates, and initial conditions, for each t , v_t solves the following agent's decision problem (with associated policy functions c_t, a'_t, ℓ_t).

$$v_t(\zeta_t) = \max_{c_t, \ell_t, a'_t} \left\{ u(c_t, \ell_t) + \beta \psi_{je} \int v_{t+1}(\zeta'_t) \Phi_{t+1}(\eta', h') d(\eta', h') \right\}$$

subject to:

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

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

$$a'_t \geq 0, \quad c_t \geq 0, \quad 0 \leq \ell_t \leq 1$$

1. Prices satisfy:

$$r_t = \alpha A_t (K_t/N_t)^{\alpha-1} - \delta$$

$$w_t = (1 - \alpha) A_t (K_t/N_t)^\alpha.$$

2. Government budgets are balanced²²:

$$\tau_t^\ell w_t \int \epsilon_{je} \xi_h \eta \ell_t(\zeta) \Phi_t(d\zeta(e = e_k)) = SS_{e_k,t} \int \Phi_t(d\zeta(e = e_k, j \geq j_r)) \quad k = 1, \dots, n,$$

where

$$SS_{e_k,t} = \frac{b_t w_t \int \epsilon_{je} \xi_h \eta \ell_t(\zeta) \Phi_t(d\zeta(e = e_k))}{\int \Phi_t(d\zeta(e = e_k, j < j_r))},$$

3. Transfers are given by:

$$Tr_{t+1} = \frac{\int (1 - \psi_{jeh}) a'_t(\zeta) \Phi_t(d\zeta)}{\int \Phi_{t+1}(d\zeta(j = 1))}.$$

4. Markets clear:

$$K_{t+1} = \int a'_t(\zeta) \Phi_t(d\zeta)$$

$$N_t = \int \epsilon_{je} \xi_h \eta \ell_t(\zeta) \Phi_t(d\zeta)$$

$$\int c(\zeta) \Phi_t(d\zeta) + K_{t+1} = Y_t + (1 - \delta) K_t.$$

5. Law of motion:

$$\Phi_{t+1} = f_t(\Phi_t)$$

where the function $f_t : \mathcal{M} \rightarrow \mathcal{M}$. Denoting $Z \equiv \{A \times E \times J \times E_d \times H\} \in \Sigma_{\mathcal{R}}$, function f_t can be written explicitly as:

(a) For all J such that $1 \notin J$:

$$\Phi_{t+1}(Z) = \int P_t(\zeta; Z) \Phi_t(d\zeta),$$

where

$$P_t(\zeta; Z) = \begin{cases} Q^\eta(\eta, E) Q_{je}^h(h, H) \psi_{jeh} & \text{if } a'_t(\zeta) \in A, j+1 \in J, e \in E_d, \\ 0 & \text{else.} \end{cases}$$

(b) For all $J = \{1\}$:

$$\Phi_{t+1}(A \times E \times \{1\} \times E_d \times H) = \begin{cases} \Pi^\eta(\mathcal{E}) \Pi^e(\mathcal{E}_d) (1 + n)^t & \text{if } 0 \in A, \bar{h} \in H \\ 0 & \text{else.} \end{cases}$$

A stationary equilibrium is a competitive equilibrium where individual policy functions, prices, tax rates, and per capita transfers are constant over time and aggregate variables grow at the same constant rate (n)

Appendix B. Robustness exercise

B.1. Exogenous infection rates

In our benchmark experiments, we have assumed that the decline in economic activity, in the first period, was brought about by a combination of government mandated lockdowns as well as individuals own willingness to self mitigate the infection risk. We would like to, next, conduct the same comparisons between targeted and random lockdown cases in a scenario where there is no self mitigation in the first period. We allow self-mitigation in the second period, though, like the benchmark. In this setting, we recalibrate the fraction of individuals subject to mandatory lockdown in the random quarantine case. The excess unemployment rate

²² $\Phi(\zeta)$ and $\Phi(\zeta(j \geq j_r))$ denote the total measure of agents and measure of retired agents respectively.

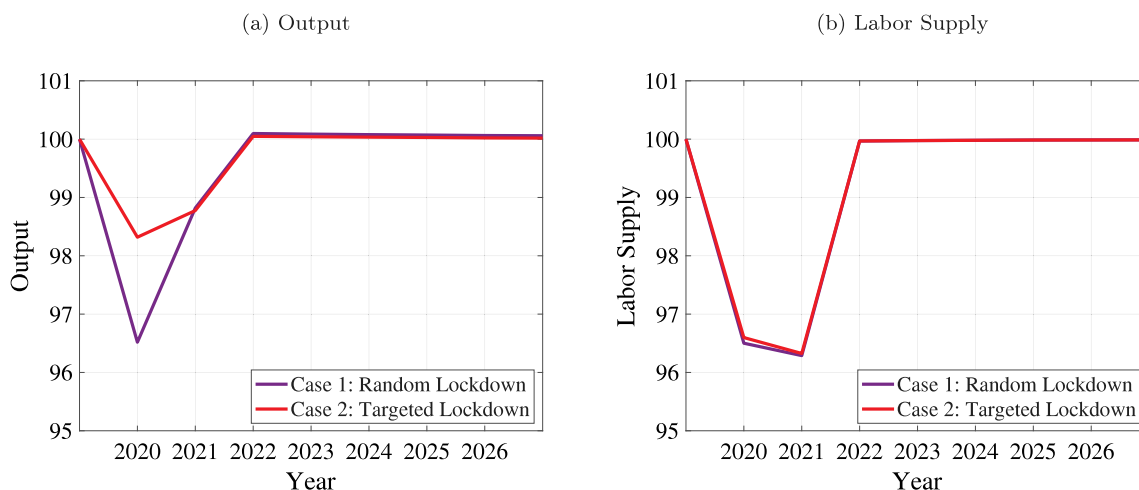


Fig. 8. Different mitigation methods: exogenous infections.

Note: Changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). In 2021, lockdown is lifted while the infection risk remains.

is now set to 3.5% to obtain the similar drop in output. In the targeted case, we impose lockdown on the 3.5% of the population, but those chosen from the vulnerable age and health groups. Specifically, we impose stay-at-home orders on those 51 years and older and in poor health, making up 3.5% of the population.

Fig. 8 shows the decline in output and labor supply under both random and targeted cases. First, note that the decline in labor supply in both cases is identical as the same number of working-age individuals is asked to stay at home. Output declines however, differ significantly. We find that while the first period drop in output in the random quarantine case is the same as benchmark (calibrated to 3.5%). The decline under targeted case is only 1.68%. This means that the economic benefits of a targeted case are somewhat larger than the benchmark (52% vs. 43%). This is due to the fact that larger the lockdown rate, larger would be the relative gains from a targeted lockdown based on age and health (both of which affect labor productivity adversely in our model).

B.2. General equilibrium

In this extension, we allow for general equilibrium effects by letting the wage rate and the interest rate to adjust in response to the COVID-19 shock. We still keep the labor income tax fixed at the baseline level to keep the theoretical framework more aligned with the actual changes that have taken place in the economy.²³ We also keep accidental bequests fixed at the baseline levels. We find that with this alternate modeling specification, output decline under all cases in the first period, as we well as in the second period, remains lower compared to the benchmark cases. This is not surprising given the closed economy assumption — there is no decline in capital due to the lockdown policies. Rather, the drop in aggregate labor supply due the lockdown results in anywhere between 1.4 and 3.2% drop in interest rate, in the first period, depending on the mitigation scenario (refer to Fig. 9(c)). Even though the output decline in all cases is relatively smaller due to changes in interest rate, aggregate labor supply (extensive margin) changes are still identical to benchmark despite small increases in wage rate. The relative difference between the random and age-health-based lockdown cases remains very similar as we find that the output decline would have been 42% smaller under the latter scenario.

B.3. Value of statistical life

In our benchmark analysis, \underline{u} is calibrated to a VSL of 3 million. This parameter is especially important for determining how many individuals self-mitigate the infection risk without any publicly mandated lockdowns. We test the sensitivity of our results to this parameter by calibrating \underline{u} to a higher value of statistical life (7.5 million) than the benchmark. As expected, we find that with a higher value of life, individuals now respond more aggressively to the same COVID-related mortality risk. This is evident by a much higher output decline in all three cases induced by greater non labor market participation. Labor supply under the random quarantine case now drops by 10.7% resulting in a 6.7% drop in output even with the same public mandated lockdown rate of 2%. The additional decline now comes from greater willingness on part of individuals to mitigate the infection risk (see Fig. 10).

²³ Labor income taxes have remain unchanged and transfer related to the pandemic have been largely debt-financed.

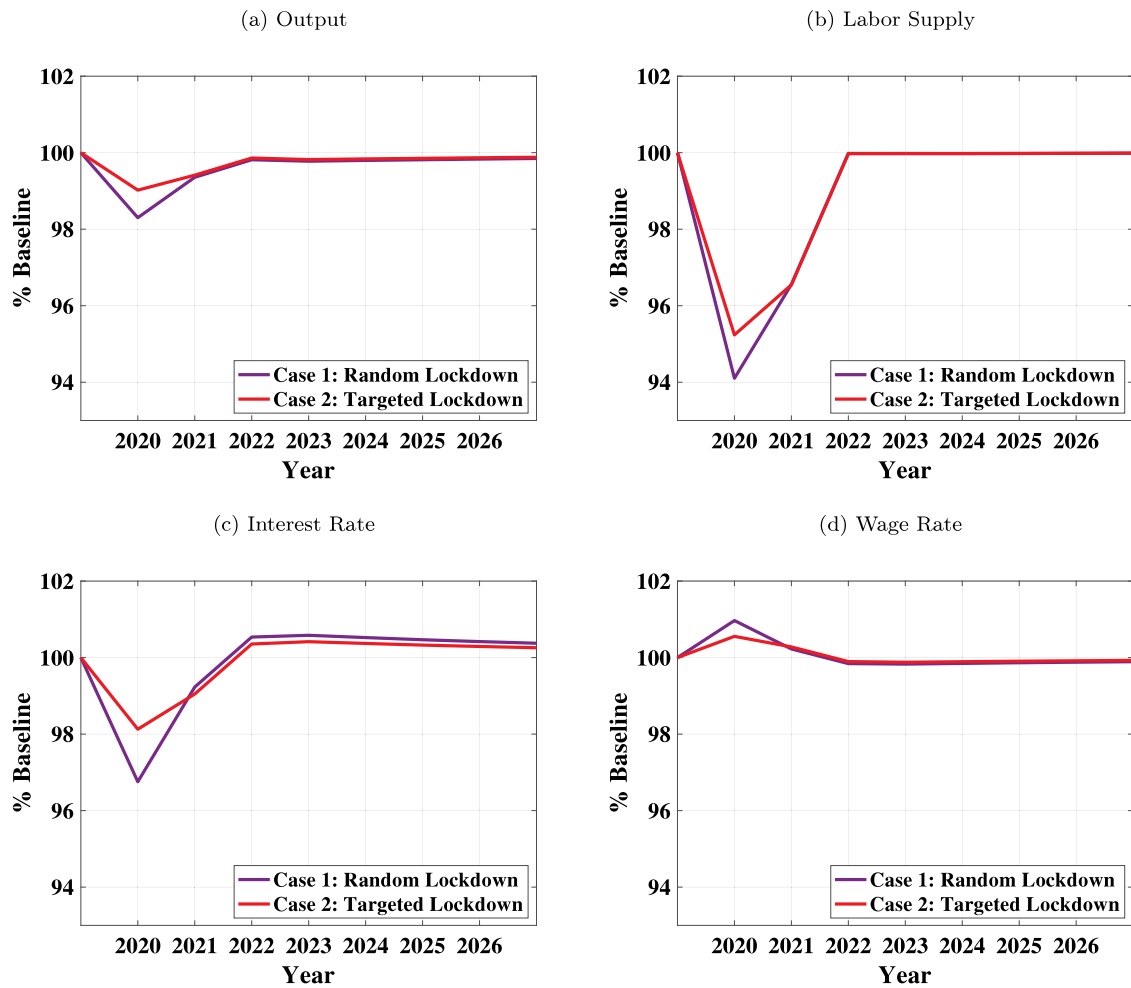


Fig. 9. Different mitigation methods: general equilibrium.

Note: Changes in output, labor supply, interest rate and wage under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). In 2021, lockdown is lifted while the infection risk remains.

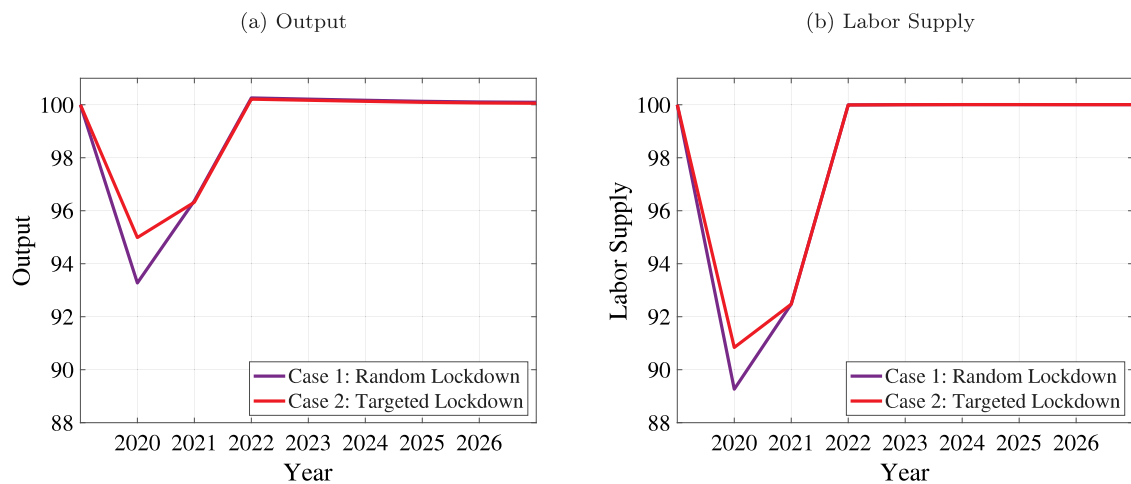


Fig. 10. Different mitigation methods: value of statistical life.

Note: Changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). In 2021, lockdown is lifted while the infection risk remains.

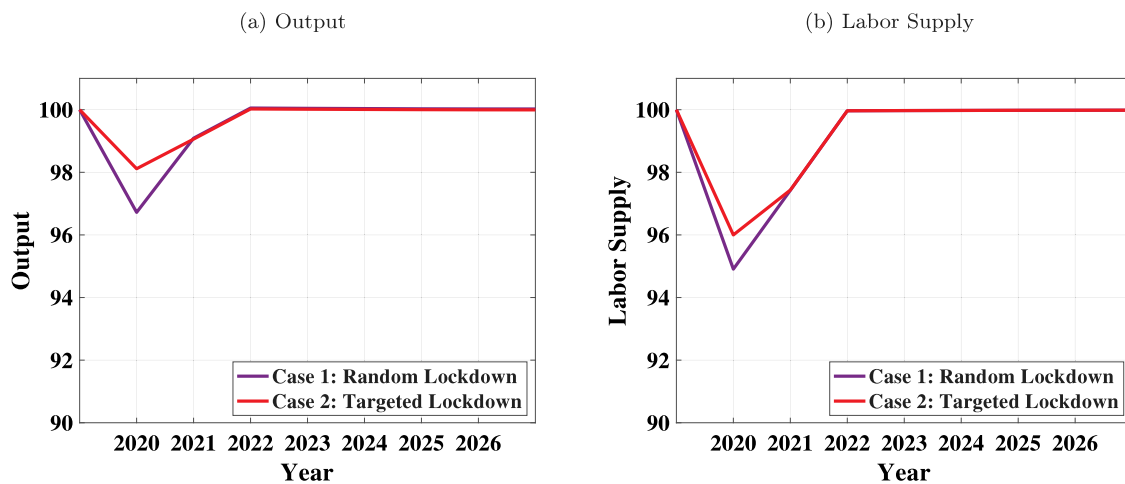


Fig. 11. Different mitigation methods: utility weight on leisure.

Note: Changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). In 2021, lockdown is lifted while the infection risk remains.

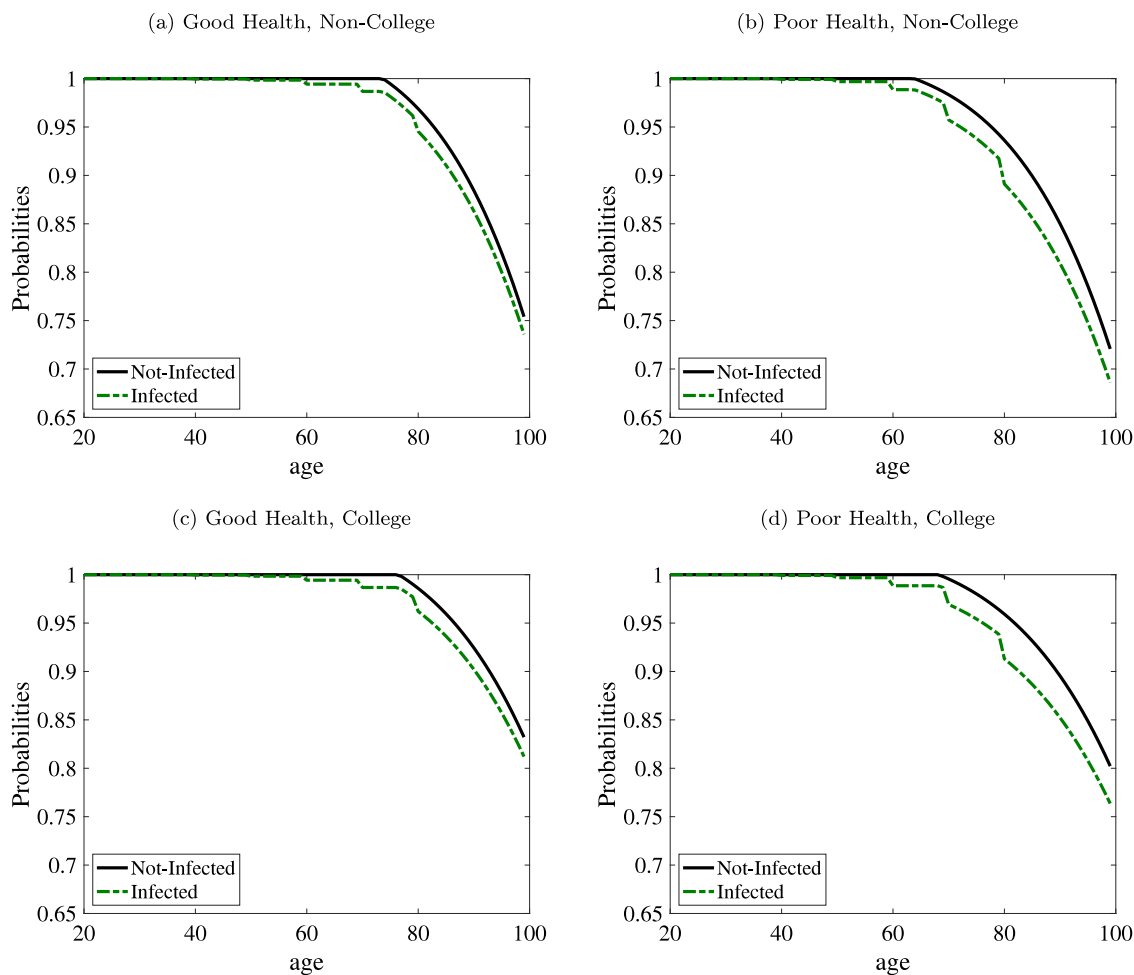


Fig. 12. Survival probability by infection status in 2020.

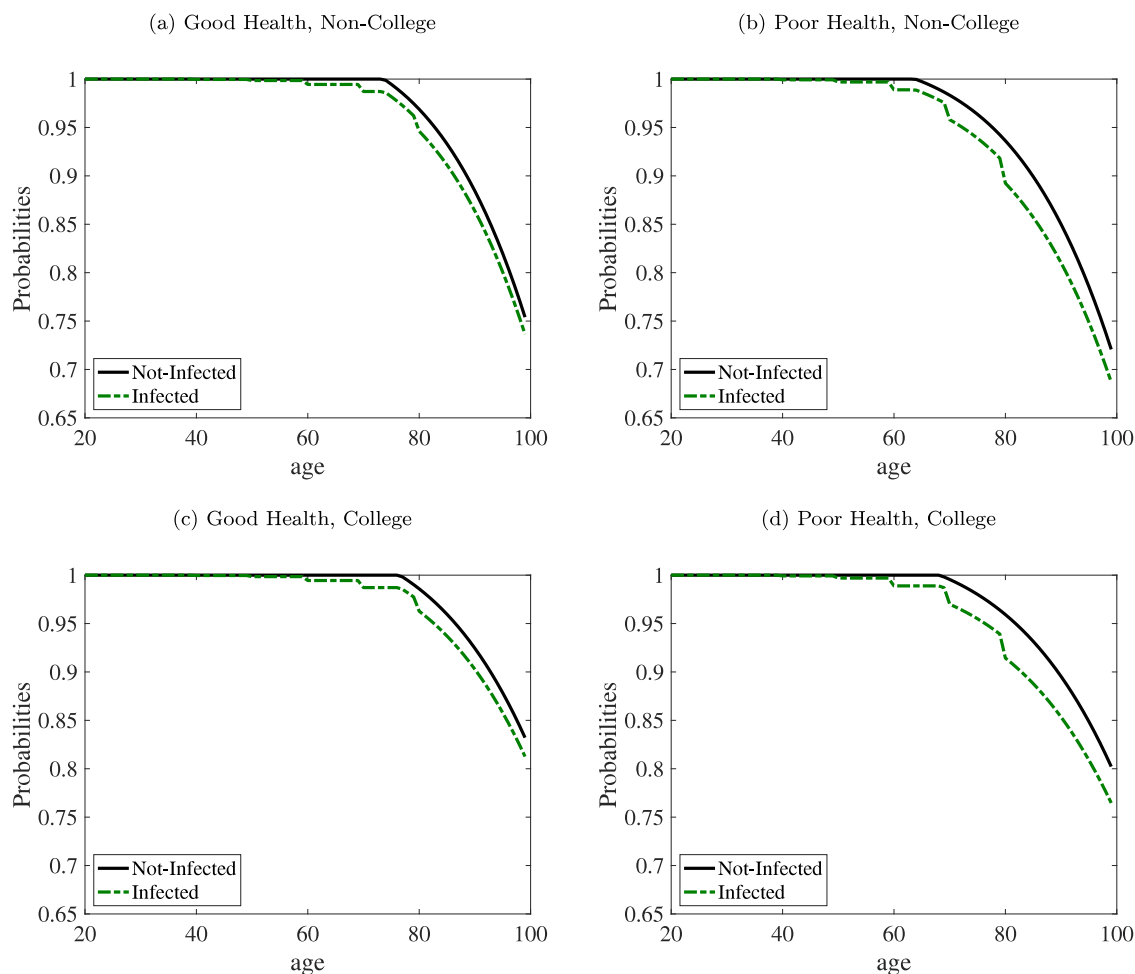


Fig. 13. Survival Probability By Infection Status in 2021.

B.4. Utility weight on leisure

Individual's willingness to self-isolate crucially depend on how much they value leisure, in other words the weight on leisure in the utility function $1 - \gamma$. With a benchmark calibration of $\gamma = 0.39$, individuals value leisure more than consumption. Next, we set $\gamma = 0.5$ and run the baseline transitions as well as the experiments with this new value.²⁴ As expected, we find that the labor supply, hence output declines under all three cases are somewhat smaller compared to benchmark cases. For instance, output declines by 3.3%, 1.89% and 1.31% under cases 1, 2 and 3 respectively (3.5%, 2.01% and 1.53% in benchmark). However, the relative benefit of a targeted lockdown, in terms of output decline, still remains identical to the benchmark at 43% (see Fig. 11).

Appendix C. Additional figures and tables

See Figs. 12–14.

Appendix D. Supplementary data

Supplementary material related to this article can be found online at <https://doi.org/10.1016/j.euroecorev.2022.104266>.

²⁴ Note that this also implies that σ changes to 3.0. One way to conduct this sensitivity test would be to re-calibrate the other preference parameters so that we are still able to match the same targets. However, we are no longer able to match hours worked to a third if we set $\gamma = 0.5$.

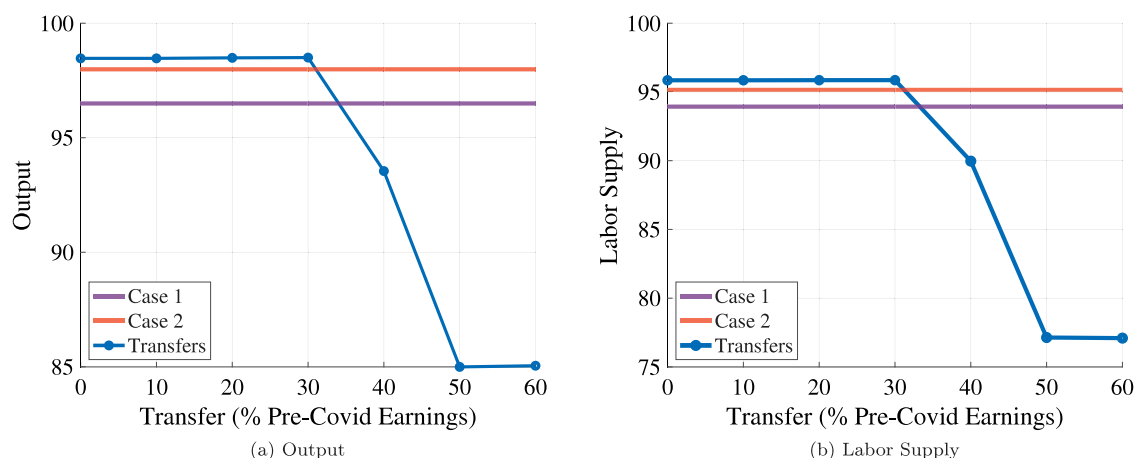


Fig. 14. Output and labor supply under need-based tax and transfers schemes.

Note: changes in output and labor supply under different lockdown cases in 2020: Case 1 (random); Case 2 (based on age and health). Transfers refer to the scenario without mandatory lockdowns but individuals are given a percent of one's own pre-COVID-19 steady state earnings for staying at home. These are financed by lump-sum taxes paid by all.

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