Trading Off Consumption and COVID-19 Deaths

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Abstract

This short note develops a framework for thinking about the following question: What is the maximum amount of consumption that a utilitarian welfare function would be willing to trade off to avoid the deaths associated with COVID-19? Our baseline answer is 26%, or around 1/4 of one year's consumption.

1. Introduction

Economies throughout the world are faced with a terrible question: how should we trade off large declines in consumption and GDP versus deaths from COVID-19? As is well appreciated in economics, individuals make life-and-death decisions every day when deciding what job to take or whether to drive across town. We apply the basic framework used to evaluate these kinds of individual decisions to a utilitarian social welfare function to help us think about trading off consumption of survivors versus deaths from COVID-19.[2]

To see our basic result, suppose that, absent any actions, COVID-19 would lead to a death rate of δ among a population with an average remaining life expectancy of LE years (say $LE = 10$), and suppose this at-risk population constitutes 1 in N people (say 1 in 6). Let v denote the value of a year of life measured in years of per capita consumption; for example if a year of life is worth \$150,000 and per capita consumption is \$50,000, then $v = 3$. The basic result of our calculation is that, to avoid this risk,

[1] We are grateful to Romans Pancs for helpful comments.

[2] Classic references include Schelling (1968) and Usher (1973). Arthur (1981), Shepard and Zeckhauser (1984), and Murphy and Topel (2003) estimate the willingness to pay to reduce mortality risk and calculate the value of life. Nordhaus (2003) and Becker, Philipson and Soares (2005) conclude that increases in longevity have been roughly as important to welfare as increases in non-health consumption, both for the United States and for the world as a whole. Hall and Jones (2007) use a related framework to study the rise in health spending as a share of GDP. Jones and Klenow (2016) construct consumption-equivalent welfare measures across countries and over time for combining consumption, life expectancy, leisure, and inequality.

society would be willing to give up a fraction of one year's consumption given by

$$\begin{aligned}\alpha &= \frac{\delta \cdot v \cdot LE}{N} \\ &= 5 \cdot \delta\end{aligned}$$

where the second equation takes as an example $v = 3$, $LE = 10$, and $N = 6$. In other words, for each percentage point of mortality from COVID-19, society is willing to give up 5 percent of consumption for a year to avoid the risk. If $\delta = 4\%$, this would mean 20 percent of consumption.

The decline in consumption is plausibly a lower bound on the decline in GDP one would be willing to accept, as one could smooth the decline in GDP over time through falling investment.

2. Model with Young and Old

Suppose lifetime utility for a person of age a is

$$\begin{aligned}V_a &= \sum_{t=0}^{\infty} \beta^t \cdot S(a,t) \cdot u(c_t) \\ &= u(c_0) + \beta \cdot S(a,1) \cdot V_{a+1}\end{aligned}$$

where $S(a,t)$ is the probability a person survives t years if they are age a at date 0.

Suppose there are two groups, young and old. The old constitute the fraction $1/N$ of the population. COVID-19 means that the survival rate for the old falls from S to $S - \delta$ for one period. The question is: what fraction α of consumption is everyone willing to give up to avoid this risk?

Let $W(\lambda, \delta)$ denote utilitarian social welfare if c_0 is reduced by λ and the COVID death rate is δ:

$$\begin{aligned}W(\lambda,\delta) &= (N-1) \cdot V_y + 1 \cdot V_o \\ &= (N-1) \cdot [u(\lambda c_0) + \beta S_y V_{F,y}] + [u(\lambda c_0) + \beta(S_o - \delta) V_{F,o}] \\ &= N u(\lambda c_0) + (N-1)\beta S_y V_{F,y} + \beta(S_o - \delta) V_{F,o}\end{aligned}$$

where V_F is the continuation utility.

The equivalent variation satisfies $W(\lambda, 0) = W(1, \delta)$:

$$Nu(\lambda c_0) + (N-1)\beta S_y V_{F,y} + \beta S_o V_{F,o} = Nu(c_0) + (N-1)\beta S_y V_{F,y} + \beta(S_o - \delta)V_{F,o}$$
$$\Rightarrow \quad N[u(\lambda c_0) - u(c_0)] = -\beta\delta V_{F,o}$$

Now, take a Taylor expansion around $\lambda = 1$ to see that

$$u(\lambda c_0) \approx u(c_0) + u'(c_0)c_0(\lambda - 1).$$

Plugging this in above gives

$$1 - \lambda = \frac{\beta\delta}{N} \cdot \frac{V_{F,o}}{u'(c_0)c_0}$$

Let $\alpha \equiv 1 - \lambda$ (so that α is the fraction of consumption you give up, a number like 5%).

Finally, assume $V_{F,o} \equiv u(c_0) \cdot LE_o$ where LE_o is the life expectancy of the old in the absence of COVID-19.[3] Then let $v \equiv u(c)/[u'(c)c]$ denote the value of a year of life relative to consumption (e.g. a number like 3). Also, we choose $\beta = 1$ so there is no time discounting apart from mortality risk. These assumptions give us our key expression for the equivalent variation:

$$\boxed{\alpha = \frac{\delta \cdot v \cdot LE_o}{N}} \tag{1}$$

That is, the fraction of consumption that a utilitarian social planner is willing to give up in order to avoid an increase in the probability of death δ is the product of the increase, the value of a year of life in units of annual consumption, and the remaining life expectancy of the group facing the mortality risk.

2.1. A Representative Agent Calibration

To get started, we first consider a calibration in which there is only a single representative agent in the economy, rather than two or more groups. In terms of the model just described, we set $N = 1$ so that everyone is effectively in the "old" group that faces

[3] This allows us to calibrate using the value of a year of life rather than the value of life. It can be justified by assuming $\beta = 1$ and a constant smoothed flow of consumption over the lifetime. Alternatively, the calculation can just be conducted with the value of a (full) life itself for the old group.

the COVID-19 mortality risk and everyone can choose to give up some fraction of one-year's consumption to avoid that risk.

According to the Imperial College London study by Ferguson et al. (2020), the death rate for all ages from COVID-19 would be 0.81% without mitigation efforts. This is the product of their age-specific mortality rates and the assumption that 75% of all age groups contract the virus in the absence of mitigation. As mentioned, a typical estimate would be $v = 3$, so that a year of life is worth roughly 3 times annual consumption (Viscusi and Aldy, 2003). Based on life expectancy tables, the life expectancy of victims would average 14.47 years.[4] Taking the product of these parameters with $N = 1$ in equation (1) yields $\alpha = 0.352$. Thus a representative agent would be willing to sacrifice over 1/3 of a year's consumption to avoid deaths from COVID-19, according to the calculation with the Taylor approximation.

Robustness. Table 1 provides this baseline estimate, as well as estimates for different values of δ and v. It also shows results using CRRA utility with $\gamma = 2$ rather than the Taylor series linearization. In our baseline case, avoiding 0.81% more mortality for the population would be worth losing 26% of consumption for the entire population for a year with $\gamma = 2$, compared to 35.2% with linearization. This calculation is the source of the number cited in the abstract.

2.2. Calibrating the Young and Old Model

We now consider an alternative calibration in which the mortality risk is entirely concentrated on the old. According to the Imperial College London study by Ferguson et al. (2020), the population-weighted death rate for those 65 and older from COVID-19 would be 3.86% without mitigation efforts. This is the product of their age-specific mortality rates and the assumption that 75% of all age groups contract the virus in the absence of mitigation.

As above, a typical estimate would be $v = 3$, so that a year of life is worth roughly 3 times annual consumption.

Using the age distribution and life expectancy in the U.S. age and sex, remaining

[4]Our calculations from https://data.census.gov/cedsci/table?q=population&tid=ACSDP1Y2018.DP05 and https://www.ssa.gov/oact/STATS/table4c6_2015.html.

Table 1: Willing to Give Up What Percent of Consumption? (Representative Agent)

Mortality rate, δ (percent)	— Value of Life, v — 2	3	4
Using Taylor series linearization:			
0.41	11.7	17.6	23.4
0.81	23.4	35.2	46.9
1.62	46.9	70.3	93.8
Using CRRA utility with $\gamma = 2$:			
0.41	10.5	15.0	19.0
0.81	19.0	26.0	31.9
1.62	31.9	41.3	48.4

Note: The first panel reports the results using equation (1), i.e. using the Taylor approximation for $u(c)$. The second panel is exact but requires us to specify a utility function. We assume $u(c) = \bar{u} + c^{1-\gamma}/(1-\gamma)$. The formula then becomes

$$\lambda_{\mathit{full}} = [1 + (\gamma - 1)\alpha]^{\frac{1}{1-\gamma}}$$

where α is the expression given in equation (1), and the full result is given by $\alpha_{\mathit{full}} = 1 - \lambda_{\mathit{full}}$.

years for those 65 and older is $LE_o = 10.9$, so that old would live 10.9 more years in the absence of COVID-19.[5]

Say $N = 6$ so there are 5 young people for each old person (e.g., 16% of the U.S. population was 65 and older in 2018, according to https://www.statista.com/statistics/270000/age-distribution-in-the-united-states/).

Using these values, the utilitarian equivalent variation is 21% of consumption for a virus that raises the mortality rate for the old group by 3.86 percentage points using equation (1). The contrast between this figure and our earlier 35% estimate based on all ages suggests that the majority (60%) of costs are borne by those 65 and older, but that a significant fraction (40%) of the costs are associated with younger ages.

Table 2 provides this baseline estimate, as well as estimates for different values of δ and v. It also shows results using CRRA utility with $\gamma = 2$ rather than the Taylor series linearization. In our baseline case, avoiding 3.86% more mortality for the old would be worth losing 17% of consumption for the entire population for a year with $\gamma = 2$, compared to 21% with linearization.

2.3. Robustness

The framework could readily be extended to capture:

- A richer mortality structure
- GDP vs. consumption
- Lost leisure during mitigation efforts
- The poor bearing the brunt of the consumption loss
- The old enjoying leisure (not working)
- Capital bequeathed to survivors

[5]Our calculations from https://data.census.gov/cedsci/table?q=population&tid=ACSDP1Y2018.DP05 and https://www.ssa.gov/oact/STATS/table4c6_2015.html.

Table 2: Willing to Give Up What Percent of Consumption?

Mortality rate, δ (percent)	— Value of Life, v — 2	3	4
Using Taylor series linearization:			
2	7.3	10.9	14.5
3.86	14.0	21.0	28.0
5	18.2	27.2	36.3
Using CRRA utility with $\gamma = 2$:			
2	6.8	9.8	12.7
3.86	12.3	17.4	21.9
5	15.4	21.4	26.7

Note: The first panel reports the results using equation (1), i.e. using the Taylor approximation for $u(c)$. The second panel is exact but requires us to specify a utility function. We assume $u(c) = \bar{u} + c^{1-\gamma}/(1-\gamma)$. The formula then becomes

$$\lambda_{full} = [1 + (\gamma - 1)\alpha]^{\frac{1}{1-\gamma}}$$

where α is the expression given in equation (1), and the full result is given by $\alpha_{full} = 1 - \lambda_{full}$.

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