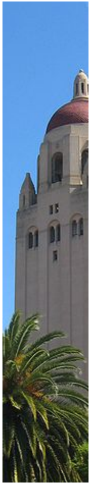

Trading Off Consumption and COVID-19 Deaths

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Basic Idea with a Representative Agent

- Pandemic lasts for one year
- Notation:
    - δ = elevated mortality this year due to COVID-19 if no social distancing
    - v = value of a year of life relative to annual consumption
    - LE = remaining life expectancy in years
    - α = % of consumption willing to sacrifice this year to avoid elevated mortality
- Key result:

$$\alpha \approx v \cdot \delta \cdot LE$$

Simple Calibration

- v = value of a year of life relative to annual consumption
  - E.g. $v = 5 \approx$ \$237k/\$45k from the U.S. E.P.A.'s recommended value of life
    $\Rightarrow$ each life-year lost is worth 5 years of consumption
- $\delta \cdot LE$ = quantity of life years lost from COVID-19 (per person)
  - $\delta = 0.81\%$ from the Imperial College London study
  - LE of victims $\approx$ 14.5 years from the same study
- Implied value of avoiding elevated mortality

$$\alpha \approx v \cdot \delta \cdot LE = 5 \cdot 0.8\% \cdot 14.5 \approx \textbf{59\% of consumption}$$

(Too high because of linearization and mortality rate)

Welfare of a Person Age a

Suppose lifetime utility for a person of age a is

$$V_a = \sum_{t=0}^{\infty} \overline{S}_{a,t}\, u(c)$$

- No pure time discounting or growth in consumption for simplicity
- $u(c)$ = flow utility (including the value of leisure)
- $\overline{S}_{a,t} = S_{a+1} \cdot S_{a+2} \cdot \ldots \cdot S_{a+t}$ = the probability a person age a survives for the next t years
- S_{a+1} = the probability a person age a survives to $a+1$

Welfare across the Population in the Face of COVID-19

- $W(\lambda, \delta)$ is utilitarian social welfare (with variations λ and δ)

- In initial year: scale consumption by λ and raise mortality by δ_a at each age:

$$
\begin{aligned}
W(\lambda, \delta) &= \sum_a N_a V_a(\lambda, \delta_a) \\
&= Nu(\lambda c) + \sum_a (S_{a+1} - \delta_{a+1}) N_a V_{a+1}(1, 0)
\end{aligned}
$$

where

- N = the initial population (summed across all ages)
- N_a = the initial population of age a

How much are we willing to sacrifice to prevent COVID-19 deaths?

$$W(\lambda, 0) = W(1, \delta)$$

$\Rightarrow$

$$\alpha \equiv 1 - \lambda \approx \sum_a \omega_a \cdot \delta_{a+1} \cdot \widetilde{V}_a$$

- $\omega_a \equiv N_a / N$ = population share of age group a
- $\widetilde{V}_a \equiv V_a(1,0) / \left[u'(c)c\right]$ = VSL of age group a relative to annual consumption

More intuitive formulas

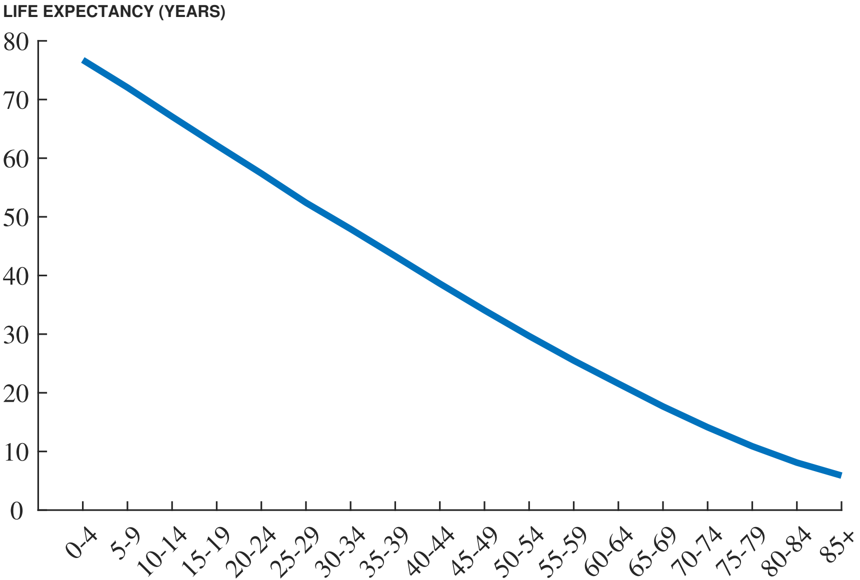
$$\alpha = \sum_a \omega_a \cdot \delta_{a+1} \cdot v \cdot LE_a$$

- $V_a(1,0)/\left[u'(c)c\right]$ = $v \cdot LE_a$ = the value of a year of life times remaining life years
- $v \equiv u(c)/\left[u'(c)c\right]$ = the value of a year of life (relative to consumption)

In the representative agent case this simplifies to

$$\alpha = \delta \cdot v \cdot LE$$

Life Expectancy by Age Group



COVID-19 Mortality by Age Group

Willing to Give Up What Percent of Consumption?

Average mortality rate δ	— Value of Life, v — 4	5	6
Using Taylor series linearization:			
0.81%	47.0	**58.7**	70.5
0.30%	17.5	21.8	26.2
Using CRRA utility with $\gamma = 2$:			
0.81%	32.0	37.0	41.3
0.30%	14.9	**17.9**	20.7

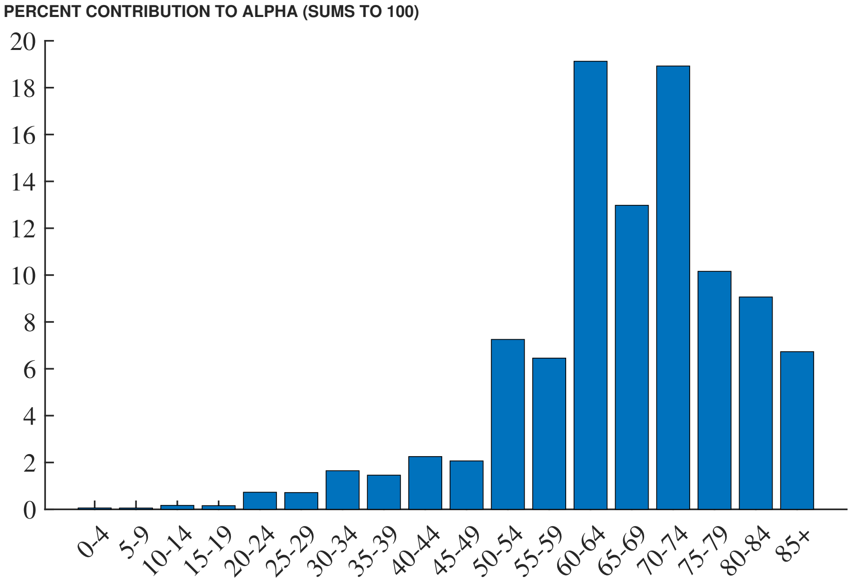
Points worth emphasizing

- 59% is the same as with a representative agent because of linearization
- 37% under CRRA due to diminishing marginal utility
    - Willing to sacrifice less when rising marginal pain from lower consumption
- The mortality rates are unconditional; rates conditional on infection would be higher
- **With 0.3% mortality and CRRA (our preferred case), willing to give up 18%**

Why entertain lower death rates?

- Undercounting may be more serious for cases than for deaths
- See studies in Italy, Iceland, and Germany, and in California counties
- Jones and Fernandez-Villaverde (2020):
  - Estimate SIRD model by country, state, and city using deaths across days
  - Find best-fitting δ is closer to 0.3% than 0.8%
- Need to test representative sample of population as emphasized by Stock (2020)

Contribution of Different Age Groups to α



Comparison to a few other estimates

- CRRA and 0.3% mortality $\Rightarrow$ willing to forego $\sim$ \$2.6 trillion of consumption
- Zingales (2020) estimated \$65 trillion
  - 7.2 million deaths vs. 1 million in our calculation
  - 50 life years remaining per victim vs. 14.5 years for us
- Greenstone and Nigam (2020) estimated \$8 trillion
  - 1.7 million deaths vs. 1 million in our calculation
  - \$315k value per year of life vs. \$225 for us

Some factors to incorporate

- GDP vs. consumption
- Capital bequeathed to survivors
- Lost leisure during social distancing
- Leisure varying by age
- Competing hazards
- The poor bearing the brunt of the consumption loss

Taking into account consumption inequality

$$\alpha \approx \delta \cdot v \cdot LE - \gamma \cdot \Delta\sigma^2/2$$

- γ is the CRRA
- σ is the SD of log consumption across people
- See Jones and Klenow (2016)

If $\gamma = 2$, each 1% increase in consumption inequality lowers α by 1%