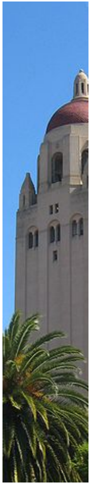

Trading Off Consumption and COVID-19 Deaths

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Basic Idea

- 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. $v = 6$ from the U.S. EPA's recommended value of life
    $\Rightarrow$ each life-year lost is worth 6 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

$$\alpha \approx v \cdot \delta \cdot LE = 6 \cdot 0.81\% \cdot 14.5 \approx \textbf{70\% of consumption}$$

Too high because of linearization

Welfare of a Person Age a

Suppose expected 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)
- S_{a+1} = the probability a person age a survives to $a+1$
- $\overline{S}_{a,t} = S_{a+1} \cdot S_{a+2} \cdot \ldots \cdot S_{a+t}$ = the probability a person age a survives for the next t years

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, if both 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?

Answer using Equivalent Variation:

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

$\Rightarrow$

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

- $\omega_a \equiv N_a/N$ = 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

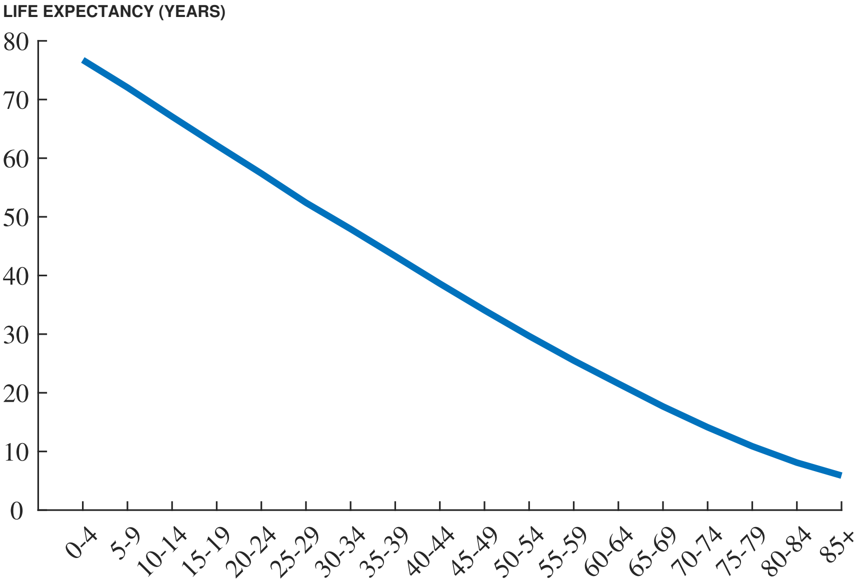
$$\alpha \approx \sum_a \omega_a \cdot \delta_{a+1} \cdot v \cdot LE_a$$

- $V_a(1,0)/\left[u'(c)c\right] = v \cdot LE_a$ = 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)

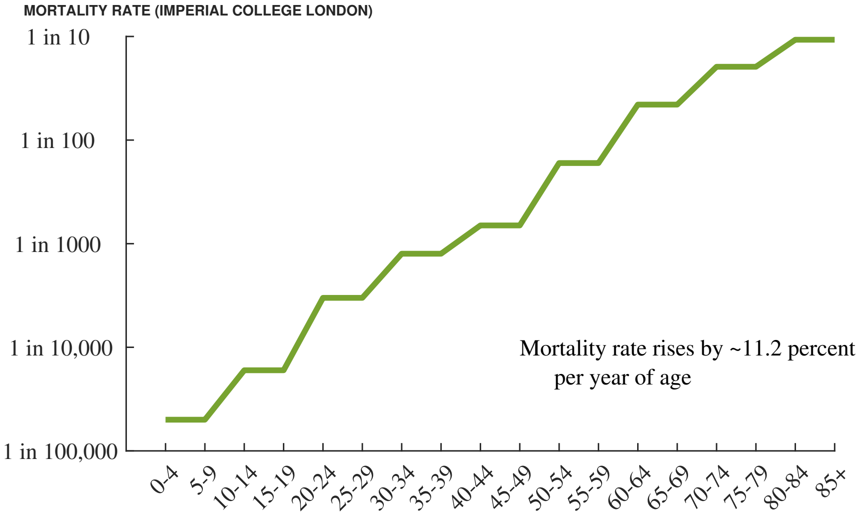
In the case of a single person this simplifies to

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

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 — 5	6	7
		Linear utility	
0.81%	58.7	**70.5**	82.2
0.44%	32.0	38.4	44.8

$$u(c) = \bar{u} + \frac{c^{1-\gamma} - 1}{1-\gamma} \text{ with } \gamma = 2$$

0.81%	37.0	**41.3**	45.1
0.44%	24.2	**27.7**	30.9

Points worth emphasizing

- 70.5% is the same as with a single person because of linearization
- 41% under diminishing marginal utility
  - Willing to sacrifice less when rising marginal pain from lower consumption
- 28% with a lower mortality rate of 0.44% (and diminishing marginal utility)
- 28% to 41% of consumption = \$12.6k to \$18.5k per person, \$4.1 to \$6.1 trillion in total

Percent of Consumption to Avoid Deaths by Age (using $\delta = 0.81\%$)

Age	% of consumption
Under 20	0.3%
Under 30	1.3%
Under 40	3.4%
Under 50	6.2%
Under 60	14.0%
Under 65	**22.9%**
Under 70	28.0%
Under 75	34.3%
Under All	41.3%

Actual and Forecast Declines in GDP

- 2020Q1 GDP down 1.25% (not annualized)
- 2020Q2 GDP forecast to fall another 10% (not annualized)
- Current forecasts say recovery will begin in 2020Q3 and last through 2022
- If so, cumulative GDP shortfall adds up to $\sim$14% of 1 year's consumption
- But not avoiding all of the 1.4 to 2.7 million deaths

VSL

- VSL $\equiv$ Value of a Statistical Life

- Economists estimate this using revealed preference
  - e.g. compensating wage differentials across risky occupations
  - consistent with some voluntary social distancing

- EPA currently uses a VSL of $7.4 million in 2006 dollars
  - We divide by 40 years of remaining life and 2006 consumption per person of $31k
  - Arrive at $\sim$6 times annual consumption ($270k today given $45k per capita)

Mortality rates

- Imperial College London estimated 1.1% conditional on infection (CFR or IFR)
  - So 0.81% unconditional if it infects 75% with no social distancing
- Seroprevalence studies since then:
  - 0.85% in New York City
  - 0.58% in Indiana (the source of our 0.44% unconditional case)
  - 1.1% in Spain (in line with the Imperial College London study)

Remaining Life Expectancy in Years (LE)

- We used 14.5 years
  - Imperial College London age-specific mortality rates
  - Age distribution of the U.S. population from the U.S. Census
  - Life expectancy by age from the U.S. Social Security Administration
- Hanlon et al. (2020) adjust for comorbidities
  - Lowers remaining LE of victims by about 1 year
  - Our estimates become 25% to 37% of consumption

Comparison to a few other estimates

- To avoid 0.81% mortality willing to forego $6.1 trillion of consumption
- Zingales (2020) estimated $65 trillion
  - 7.2 million deaths vs. 2.7 million in our calculation
  - 50 life years remaining per victim vs. 14.5 years in our calculation
  - Linear utility vs. diminishing marginal utility for us
- Greenstone and Nigam (2020) estimated $7.9 trillion
  - 1.7 million deaths vs. 2.7 million in our calculation
  - $315k value per year of life vs. $270k for us
  - Linear utility vs. diminishing marginal utility for us

Some additional factors one could try to incorporate

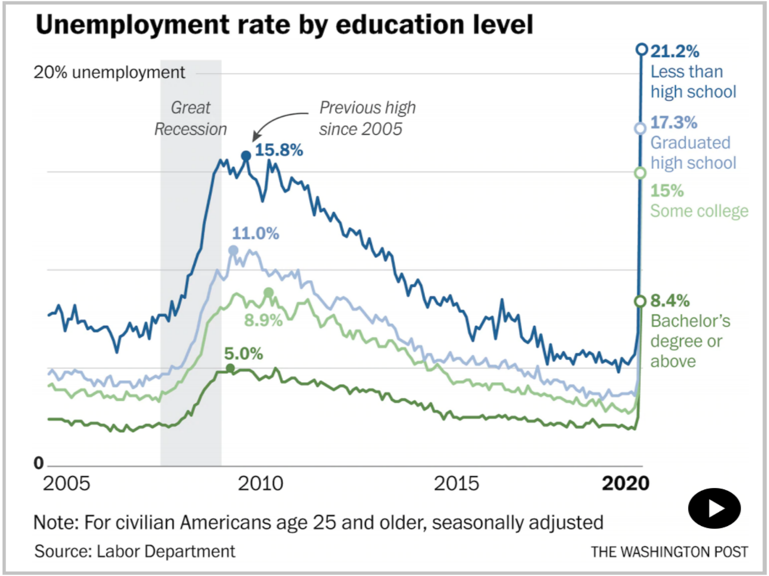
- GDP vs. consumption (see also the physical capital stock)
- Morbidity (not just mortality) from COVID-19
- Competing hazards avoided and induced by social distancing (car accidents, etc.)
- Leisure varying by age
- Lost leisure during social distancing
- Lost human capital investment during social distancing
- The poor bearing the brunt of the consumption loss

Taking into account consumption inequality

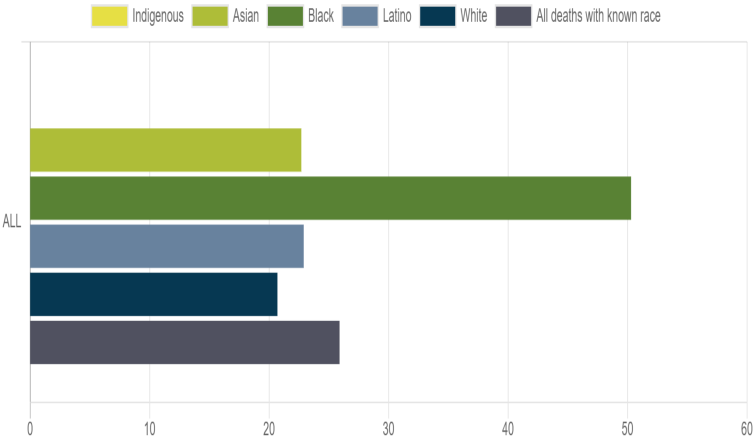
$$\alpha \approx \delta \cdot v \cdot LE - \gamma \cdot \Delta\sigma^2/2$$

- γ governs how rapidly marginal utility diminishes
- σ is the standard deviation of log consumption across people
- See Jones and Klenow (2016) “Beyond GDP” paper

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


Unemployment rate by education level
20% unemployment
Great Recession
Previous high since 2005
15.8%
11.0%
8.9%
5.0%
21.2%
Less than high school
17.3%
Graduated high school
15%
Some college
8.4%
Bachelor's degree or above
0
2005
2010
2015
2020
Note: For civilian Americans age 25 and older, seasonally adjusted
Source: Labor Department
THE WASHINGTON POST

COVID-19 DEATHS PER 100,000 PEOPLE OF EACH GROUP, REPORTED THROUGH MAY 19, 2020



Source: APM Research Lab