# Population and Welfare: The Greatest Good for the Greatest Number

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**Abstract**

Economic growth is typically measured in per capita terms. But social welfare should arguably include the number of people as well as their standard of living. We decompose social welfare growth — measured in consumption-equivalent (CE) units — into contributions from rising population and rising per capita consumption. Because of diminishing marginal utility from consumption, population growth is scaled up by a value-of-life factor that exceeds one and empirically averages nearly 3 across countries since 1960. Population increases are therefore a major contributor, and CE welfare growth around the world averages more than 6% per year since 1960 as opposed to 2% per year for consumption growth. Countries such as Mexico and South Africa rise sharply in the growth rankings, whereas China, Germany, and Japan plummet. These results are robust to incorporating time use and fertility decisions using data from the U.S., Mexico, the Netherlands, Japan, South Africa, and South Korea. Falling parental utility from having fewer kids is roughly offset by increases in the "quality" of kids associated with rising time investment per child.

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# 1. Introduction

Economic growth is almost invariably measured in *per capita* terms. The reason for this is clear: we seek to quantify the gains in living standards in the economy, and individual consumption is a key argument of people's utility functions. From the standpoint of social welfare, however, the total population of the economy arguably matters as well: a world with a billion happy people is "better" than a world with a million people if they are identical in every other way. Similarly, a catastrophe resulting in the death of half the world's population would constitute a profound tragedy, even if individual consumption levels remained constant.

Consider two hypothetical economies with exactly the same time path of total factor productivity (TFP) so that the production opportunities for these economies are the same. One country chooses to keep population constant, and all the TFP growth flows into higher per capita consumption. The other country chooses to keep its per capita consumption constant and uses the extra resources to increase its population. The traditional focus on per capita consumption says that the first country is more successful, but this seems odd given that the two countries have exactly the same production possibilities.

This hypothetical is not too far from some real world examples. Between 1960 and 2019, consumption per person increased by a factor of 6 in Japan versus a factor of 3 in Mexico. However, Mexico's population tripled while Japan's population only rose by 30 percent. Which country was more successful?

Or consider economic growth over the past 25,000 years. Until the last few centuries, technological improvements like better stone tools, the wheel, agriculture, and cities showed up as higher population rather than higher consumption per capita. Shouldn't the population growth in the Malthusian era count as progress?

When it comes to public investments in nonrival knowledge, the number of people alive to benefit in the future should matter for a social cost-benefit calculation. For example, we may be willing to spend more to mitigate global warming the larger the future population relative to today's.

This paper reconsiders the pace of economic growth across countries using a consumption-equivalent (CE) metric based on total utilitarian social welfare.[1] Stated coarsely, we endeavor to put "humans" into a Human Development Index.

To see how, consider an economy of $N_t$ identical people with consumption per person $c_t$. Let the annual flow of individual utility be $u(c_t)$. The aggregate flow of utility is then $N_t \cdot u(c_t)$, a natural version of "the greatest good for the greatest number." For a large set of countries since 1960, we calculate CE welfare growth for this metric. It is worth emphasizing that this calculation is for the *flow* of social welfare rather than a present-discounted value that takes into account the welfare of future generations. In this sense, it is more like GDP itself.

A simple version of our calculation just uses aggregate consumption growth rather than growth in consumption per person. This amounts to putting equal weight on the number of people and consumption per person. When welfare is given by $N_t \cdot u(c_t)$, however, the diminishing returns in $u(\cdot)$ implies that constant and equal weighting of consumption growth and population growth is not correct. We show that the growth rate of CE social welfare is instead given by:

$$v(c_t) \cdot g_{Nt} + g_{ct}$$

where $g_N$ and $g_c$ denote population growth and per capita consumption growth, respectively. The weight $v(c)$ on population growth is the value of a year of life measured in years of per capita consumption and is almost always greater than one because of the "consumer surplus" associated with life. In fact, we will show that the appropriate weight is typically much larger, approximately 5 in recent years for the United States, and averaging 2.7 for the world as a whole since 1960. In other words, from a social welfare standpoint, population growth is substantially more important than growth in per capita consumption.

In our results, CE welfare growth across 101 countries averages 6.2% per year between 1960 and 2019, versus average annual per capita consumption growth of

[1] Throughout the paper, we use social welfare as a shorthand for total utilitarian social welfare, also known in the literature as the Benthamite criterion.

2.1%. Population growth accounts for two thirds of CE welfare growth on average for this sample when we weight countries equally, and one half of CE welfare growth when we weight countries by their population. These numbers are also illustrative of the United States: CE welfare growth averages 6.5% per year between 1960 and 2019, versus 2.2% for per capita consumption growth.

The growth rate of CE social welfare also provides a very different perspective on the success of various countries over time. Mexico, South Africa, and Kenya move from the bottom third of growth rates to the top 60%; Mexico, for example rises from the 36th percentile to the 88th, with CE welfare growth equal to 8.6% per year. On the flip side, traditionally fast-growing countries like Germany, Japan, and China have much slower CE welfare growth because of slow population growth. Germany plummets to the 11th percentile. Similarly, Japan and China fall to the 32nd and 45th percentiles, respectively, below the United States and below the median. Overall, the correlation between CE welfare growth and per capita consumption growth across 101 countries is 0.51.

It is also important to appreciate what we are *not* doing in this paper. We use the marginal rate of substitution between population and per capita consumption to do accounting exercises along a social indifference curve. This paper is about preferences, not technology. There are lots of other interesting questions one might like to answer such as "What would optimal fertility look like?" or "Did the demographic transition reduce social welfare?" Answering these questions requires specifying the production possibilities of the economy, including things like the nonrivalry of ideas, limited resources, human capital, and pollution. Our approach is more narrow. We cannot address these richer questions, but we get by without making any assumptions about the production structure of the economy. Clearly it would be interesting for future research to make assumptions on the production side to consider such questions.

The remainder of our paper proceeds as follows. After a brief review of the literature, Section 2 lays out our basic theory and derives the expression for CE social welfare growth. Section 3 applies this framework to a broad set of countries over the period 1960 to 2019. Section 4 then explores the robustness of these results to al-

ternative calibrations of preference parameters. We also consider inequality within countries and migration across countries here. Section 5 gauges the robustness of our results to incorporating parental time use, fertility decisions, and a quantity-quality tradeoff. Using detailed time use data for the U.S., Netherlands, Japan, South Korea, Mexico, and South Africa, we find that the effects of falling parental utility from having fewer kids is roughly offset by increases in the "quality" of kids associated with rising parental time investments per child. That is, detailed calculations with rich micro data confirm that the simpler calculations in the first half of the paper are robust. Finally, Section 6 concludes.

**Related literature.** Parfit (1984) posed the "repugnant conclusion" challenge to total utilitarianism. This challenge holds that trying to maximize total welfare could result in an undesirable outcome in the form of many people being alive but enjoying very low flow utility per capita. On the other hand, Harsanyi (1955), Hammond (1992), and Gustafsson, Spears and Zuber (2023) provide axiomatic approaches under which seemingly reasonable assumptions imply total utilitarianism. Considering such arguments, 29 philosophers and economists offer reasons to entertain total utilitarianism in spite of the repugnant conclusion (Zuber et al., 2021). MacAskill (2022) provides a detailed and nuanced case for a total utilitarian perspective.

Golosov, Jones and Tertilt (2007) propose two Pareto efficiency criteria for assessing outcomes when population levels are endogenous due to fertility choices. In contrast, we embrace a social welfare function featuring total utility and hence can quantitatively compare outcomes with different population levels.

Young (2005) analyzes the impact of the AIDS epidemic in South Africa. His focus is the impact of the epidemic on the fertility, education, and consumption decisions of survivors. He does not quantify the losses from death itself, though he does discuss how the rising income of survivors could be used to fund antiretrovirals therapy which could prevent deaths.

Cordoba (2015) explicitly analyzes how rising longevity of children (and parents) offsets fertility reductions in terms of the growth of parental living standards. He looks at the impact of the quality-quantity tradeoff on welfare in 116 countries from

1970 to 2005. Note that this stops short of total utilitarianism, but does incorporate how the quantity and quality of children affects parental welfare. He finds that declining fertility lowers welfare growth relative to standard per capita measures whereas we emphasize that positive rates of population growth raise welfare growth relative to those same measures.

Cordoba and Liu (2018) study optimal population in the presence of a fixed factor (land). This involves trading off fertility, which parents derive utility from, against lower land per capita and hence lower consumption per person. Per capita utilitarianism has been criticized for trying to maximize per capita utility without regard to the total number of people alive, which may imply choosing a very low population when there are fixed resources. Cordoba and Liu do not embrace total utilitarianism, but do incorporate a benefit to parents of having more children.

Jones and Klenow (2016) quantify CE welfare across countries and time. They incorporate consumption, leisure, life expectancy, and inequality. But their focus is entirely on *per capita* welfare.

De la Croix and Doepke (2021) propose a "soul-based utilitarian" social welfare function that postulates a fixed number of souls who can be born or not, or even reborn. They show that this nests various other social welfare functions considered in the literature, including total utilitarianism. Chichilnisky, Hammond and Stern (2020) propose a related, survival-probability weighted social welfare function.

## 2. The Framework: Aggregate Welfare

To make our point as clearly as possible, consider an economy of $N_t$ identical people, each with consumption per person $c_t$.[2] Each person gets flow utility $u(c_t)$. The total flow of welfare enjoyed by this economy is then

$$W(N_t, c_t) = N_t \cdot u(c_t).$$

Notice that this is also a standard utilitarian social welfare function.

[2] In Section 4.2, we relax the assumption of a representative agent.

Without loss of generality, the value of death is normalized to zero; we also assume that nonexistence is equivalent to death.[3] For life to be valuable, it must then be that $u(c) > 0$. In addition, we make the standard assumptions that $u$ exhibits diminishing marginal utility: $u'(c) > 0$, and $u''(c) < 0$.

There are different ways to derive the growth rate of consumption-equivalent welfare. For example, with discrete time, consider the value of $\lambda$ such that $W(N_t, c_t) = W(N_{t-1}, \lambda c_{t-1})$. We prefer continuous time because, as the time interval shrinks to zero, the compensating variation will equal the equivalent variation and we do not need to make this distinction. Moreover, there is an intuitive derivation that arrives at the right answer quickly; Appendix A.1 provides the more formal derivation of this result. Consider the growth rate of social welfare:

$$\frac{dW_t}{W_t} = \frac{dN_t}{N_t} + \frac{u'(c_t)c_t}{u(c_t)} \cdot \frac{dc_t}{c_t}$$

Interestingly, because the social welfare function is linear in $N$, the growth rate of $W_t$ is in "population-equivalent" units: the weight on population growth is one, while the weight on consumption growth is something else.

Divide both sides so that the weight on consumption growth equals one to get consumption-equivalent welfare growth:

$$\underbrace{\frac{u(c_t)}{u'(c_t)c_t} \cdot \frac{dW_t}{W_t}}_{\text{CE welfare growth}} = \underbrace{\frac{u(c_t)}{u'(c_t)c_t}}_{\equiv v(c_t)} \cdot \frac{dN_t}{N_t} + \frac{dc_t}{c_t} \tag{1}$$

This puts population growth in consumption-equivalent units, essentially using the slope of the social indifference curve. The weight on population growth is $v(c_t) \equiv \frac{u(c_t)}{u'(c_t)c_t}$. That is, $v(c_t)$ is the value of having one more person live for one period, $u(c_t)$; dividing by the marginal utility of consumption puts this in consumption units, and then because we are comparing growth rates, we further divide by per capita con-

[3] The philosophy literature notes that alternative assumptions could matter. For example, imagine using our free normalization to set pre-existence to zero. Perhaps everyone goes to heaven after dying, or perhaps hell, or perhaps some probabilistic combination of those possibilities. Absent evidence, assuming the same value before and after life is natural and useful in our view.

sumption. A percentage point of population growth is worth $v(c_t)$ percentage points of consumption growth.

A couple of brief examples are helpful for intuition. Notice that $v(c)$ is the inverse of the elasticity of utility with respect to consumption. If $u(c) = c^\alpha$, then $v(c) = 1/\alpha$. With linear utility ($\alpha = 1$), then $v(c) = 1$ and the value of a year of life equals per capita consumption. If $\alpha = 1/2$, then $v(c) = 2$. More generally, the sharper is diminishing marginal utility — the lower is $\alpha$ — the higher is $v(c)$. In general, one would expect $v(c) > 1$, capturing the "consumer surplus" associated with diminishing marginal utility.

**Measuring $v(c_t)$ in the United States in 2006.** The key weight $v(c)$ is the value of a year of life, measured in dollars, as a ratio to consumption per person. A large literature estimates the value of a statistical life (VSL) based on the compensation in wages or consumption that an individual would have to receive in order to be indifferent to facing a slightly higher probability of death; see Viscusi and Aldy (2003) for a survey. Hall, Jones and Klenow (2020) show how this is tightly connected to $v(c)$, as follows:

$$v(c_{us,2006}) \equiv \frac{u(c)}{u'(c)\cdot c} = \frac{\text{VSLY}}{c} \approx \frac{\text{VSL}/e_{40}}{c} \approx \frac{\$7,400,000/40}{\$38,000} = \frac{\$185,000}{\$38,000} \approx 4.87$$

The U.S. Environmental Protection Agency (2020) uses a VSL equal to $7.4m in 2006 prices. Given that a middle-aged American had a remaining life expectancy of around 40 years in 2006, this corresponds to a VSLY of around $185,000.[4] This is very much in line with the value of life used elsewhere. For example, the U.S. Department of Transportation (2014), citing a set of studies, suggests efficacy of safety regulations should be evaluated considering VSL's over a range of $4 to $10 million for the U.S. in 2001. Later we consider robustness to VSL values of 50% and 150% of our baseline.

[4]For simplicity, we are not discounting here. With discounting and growth in consumption, the numbers are similar; see Jones and Klenow (2016).

Consumption per person in the United States in 2006 was $38,000, including both private consumption and government consumption, which implies a value of $v(c_{us,2006}) \approx 4.87$. That is, a year of life in 2006 in the United States is valued at approximately 5 years worth of consumption per person.

**Functional form of flow utility.** To determine the value of $v(c_t)$ in other years and in other countries — and more generally to do our accounting — we would ideally have VSL estimates from many different countries and time periods. There is limited well-identified evidence of this kind, so we take a different approach. We first specify a functional form for flow utility then use that to calculate $v(c)$ at different levels of consumption. Our benchmark, which we relax in a robustness check, is

$$u(c_t) = \bar{u} + \log c_t.$$

With this functional form, the value of a year of life is given by

$$v(c_t) \equiv \frac{u(c_t)}{u'(c_t) \cdot c_t} = u(c_t) = \bar{u} + \log c_t. \tag{2}$$

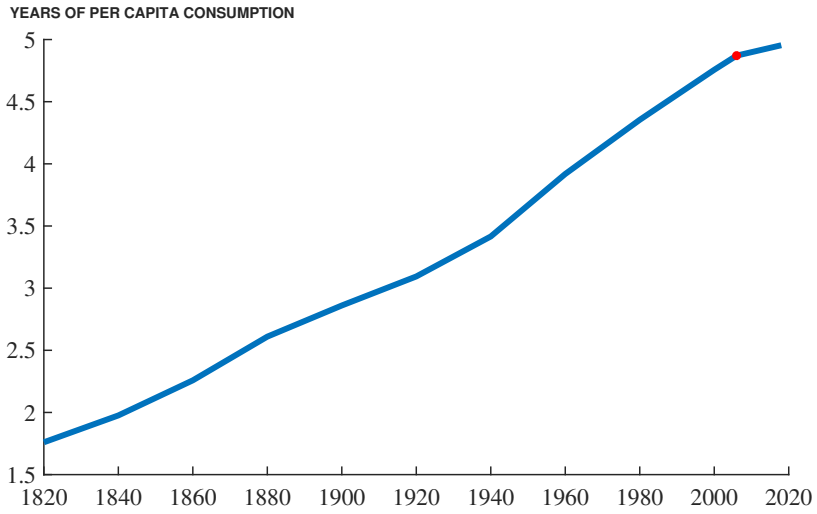
Both of these equations make clear the importance of the constant term $\bar{u}$. To calibrate its value, we choose consumption units such that $c_{us,2006} = 1$, which means that $v(c_{us,2006}) = \bar{u} = 4.87$.[5]

The other interesting thing to note about $v(c)$ from equation (2) is that it is not constant. In particular, $v(c)$ increases with the log of consumption: as living standards increase, life becomes increasingly valuable, even relative to consumption.

Using data from the National Income and Product Accounts back to 1929 and from de Pleijt and van Zanden (2020) before that, Figure 1 shows the implied value of life $v(c)$ for the United States over time. As anticipated by equation (2), this value rises roughly linearly over time, reflecting the exponential growth in consumption.

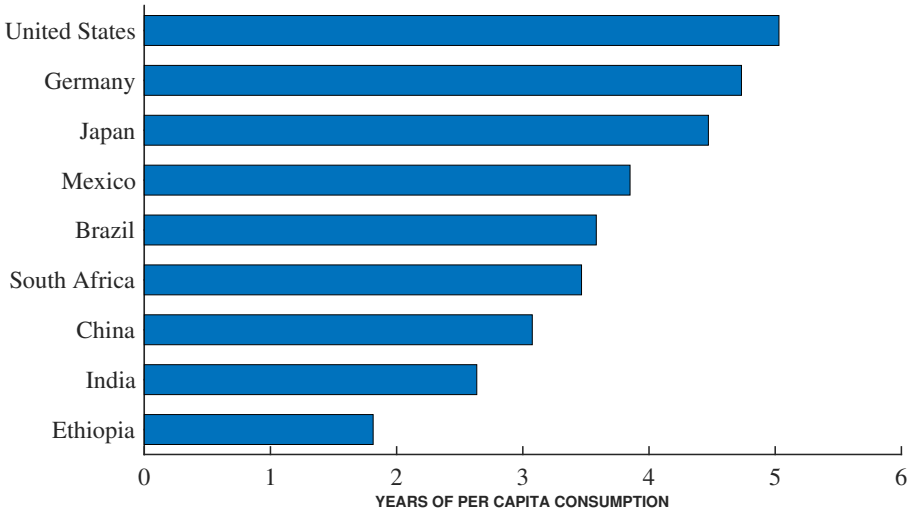
[5] If consumption is sufficiently low, then flow utility could turn negative. This issue is discussed extensively in Rosen (1988), who noted that individuals with low consumption would become risk-loving and take gambles between death and a higher level of consumption in order to convexify utility such that $v(c) = 1$ at low values of $c$. In our baseline calculations, flow utility turns out to be positive in every year and country.

Figure 1: $v(c)$ over time in the United States




Note: $v(c)$ computed using log utility and data from the U.S. National Income and Product Accounts back to 1929 and from de Pleijt and van Zanden (2020) with a constant consumption share of GDP before that.

Figure 2: $v(c)$ across countries in 2019




Note: $v(c)$ computed using data from the Penn World Tables 10.0 assuming log utility.

The value is slightly below 2 in 1820 and rises to nearly 5 by 2019.

Figure 2 shows the values of $v(c)$ for a cross-section of some of the most populous countries in the world in 2019 using the Penn World Table 10.0. Interestingly, the range of values in the world's cross section for 2019 is similar to the historical U.S. values back to 1820, ranging from a low of just under 2 for Ethiopia to the high of 5 for the United States. The average value across 101 countries in 2019 is 2.7. Kremer et al. (2023) cite and use World Health Organization thresholds for valuing a life year of one to three times per capita GDP. This implies roughly 1.5 to 4.5 times per capita consumption, which is remarkably close to the range across our countries.

**Summary.** Consumption-equivalent social welfare growth, $g_\lambda$, is the sum of per capita consumption growth and population growth, where population growth is scaled by the value of a year of life relative to consumption, $v(c)$:

$$g_\lambda = v(c) \cdot g_N + g_c. \tag{3}$$

Because $v(c)$ is in the range of 2 to 5, population growth gets a much higher weight than consumption growth. The remainder of the paper applies this equation empirically.

When implementing this calculation, we always use annual data and then average the result over longer time periods. When annual data are not available, for example in looking at data back to the 1800s or 1500s, we interpolate between the observations assuming a constant growth rate and then proceed as if we have annual data. This strikes us as the best way to treat the data given the changing $v(c_t)$ over time. It is closest to our continuous-time derivation and allows us to avoid the usual "CV" versus "EV" discrepancy.

## 3. Results: Consumption-Equivalent Social Welfare Growth

**Data.** For the period 1960–2019, we use the Penn World Table 10.0, an updated version of Feenstra, Inklaar and Timmer (2015), which gives us a large sample of

Table 1: Overview of Results from 1960 to 2019

| | Unweighted | Pop Weighted |
|---|---|---|
| CE-welfare growth, $g_\lambda$ | 6.2% | 5.9% |
| Population term, $v(c)g_N$ | 4.1% | 3.1% |
| Consumption term, $g_c$ | 2.1% | 2.8% |
| Population growth, $g_N$ | 1.8% | 1.6% |
| Value of life, $v(c)$ | 2.7 | 2.3 |
| Pop share of CE-welfare growth | 66% | 51% |

Notes: In 77 of the 101 countries, the population share of CE welfare growth exceeds 50%.

101 countries. Consumption is calculated as the sum of private consumption and government consumption.[6]

### 3.1 Macro Results for 1960 to 2019

Table 1 summarizes our results for the 101-country sample from the Penn World Table, applying equation (3) annually and taking the average. While growth in consumption per person averages 2.1% per year between 1960 and 2019, CE welfare growth is substantially higher at 6.2% per year. Growing at 2.1% per year, average living standards double every 33 years. But taking into account population growth as well, social welfare doubles every 12 years in this sample. The 4.1 percentage point difference between consumption growth and social welfare growth is accounted for by the fact that population growth averages 1.8 percent per year and the value of life $v(c)$ over this period has an average value equal to 2.7 years of consumption (covariances mean that the average of the product, 4.1 percent, is not equal to the product of these averages). Population growth accounts for 66% of social welfare growth on average across the 101 countries; weighting countries by their population, which gives China a large role, the population share of welfare growth falls to 51%.

[6]The PWT has consumption data for 111 countries since 1960, but we drop any country labelled by the dataset as an outlier in any of the sample years.

Table 2: Decomposing Welfare Growth in Select Countries, 1960–2019

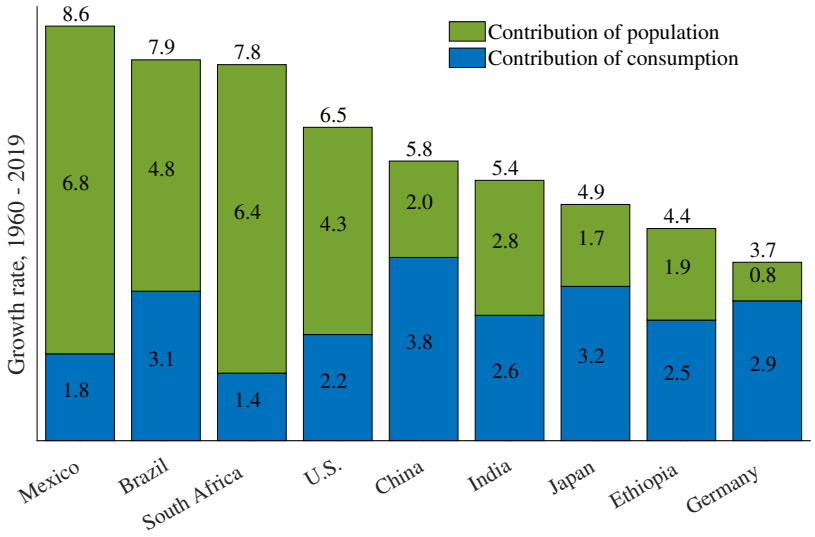
| | $g_\lambda$ | $g_c$ | $g_N$ | $v(c)$ | $v(c) \cdot g_N$ | Pop Share |
|---|---|---|---|---|---|---|
| Mexico | 8.6 | 1.8 | 2.1 | 3.4 | 6.8 | 79% |
| Brazil | 7.9 | 3.1 | 1.8 | 2.8 | 4.8 | 61% |
| South Africa | 7.8 | 1.4 | 2.1 | 3.1 | 6.4 | 82% |
| United States | 6.5 | 2.2 | 1.0 | 4.4 | 4.3 | 66% |
| China | 5.8 | 3.8 | 1.3 | 1.8 | 2.0 | 34% |
| India | 5.4 | 2.6 | 1.9 | 1.6 | 2.8 | 52% |
| Japan | 4.9 | 3.2 | 0.5 | 3.8 | 1.7 | 34% |
| Ethiopia | 4.4 | 2.5 | 2.7 | 0.7 | 1.9 | 44% |
| Germany | 3.7 | 2.9 | 0.2 | 4.0 | 0.8 | 22% |

Notes: $g_\lambda$ denotes consumption-equivalent social welfare growth, $g_c$ is the growth rate of per capita consumption, $g_N$ is population growth, $v(c)$ is the value of life year relative to consumption, and the population share is $v(c) \cdot g_N / g_\lambda$.

Table 2 reports the decomposition of growth in consumption-equivalent social welfare for a select sample of countries based on equation (3). To begin, consider the countries with the fastest and slowest growth in the table. Social welfare growth in Mexico averages 8.6% per year since 1960, far exceeding its modest growth in consumption per person of 1.8% per year. This is for two reasons: population growth averages more than 2% per year and Mexico's value of life factor $v(c)$ averages 3.4. Population growth accounts for 79% of social welfare growth in Mexico. At the other extreme is Germany. Its relatively higher growth rate of consumption is barely augmented by its very modest population growth of 0.2% per year even though its value of life factor is 4.0. Population growth accounts for just 22% of social welfare growth in Germany. Figure 3 shows these data graphically, in part to make comparisons with later figures easier.

To show results for a broad set of countries, Figures 4 and 5 present scatterplots of CE welfare growth against consumption growth and population growth. The range of variation in CE welfare growth is striking. Even the slowest-growing countries have growth rates of CE welfare between 1960 and 2019 that exceed 2%

Figure 3: Welfare Growth in Select Countries, 1960–2019




Notes: The numbers in the bars are CE welfare growth, the percentage point contribution from population growth, and per capita consumption growth. Data are from the Penn World Tables 10.0, an updated version of Feenstra, Inklaar and Timmer (2015).

per year. This constrasts with the negative consumption growth rates observed for a handful of countries. Equally striking is the fact that the fastest-growing countries have average annual growth rates of CE welfare that exceed 10% per year, versus a maximum of 5% per year for consumption growth.

Neither consumption growth nor population growth are especially highly correlated with CE welfare growth. The correlation with consumption growth is 0.51, while the correlation with population growth is 0.29.

Figure 6 provides a different way of illustrating the difference between our CE welfare growth and standard consumption growth measures by ranking countries from fastest to slowest growing. For example, China, Japan, and Germany are among the fast-growing countries over this period in terms of consumption growth, with China at around the 90th percentile. Slow population growth in these countries moves them sharply down in the distribution of CE welfare growth, with Germany falling to just the 11th percentile and China falling to the 44th percentile.

Figure 4: Plot of CE growth against consumption growth, 1960-2019

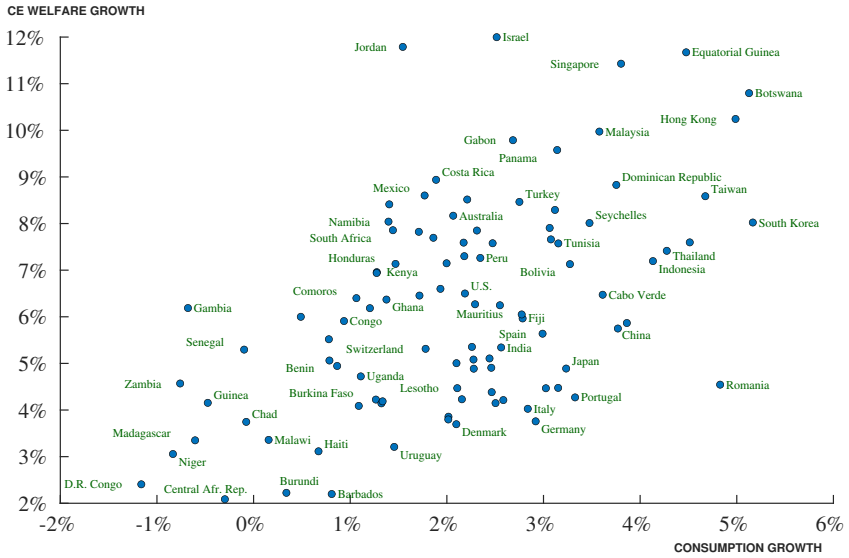



Figure 5: Plot of CE growth against population growth, 1960-2019

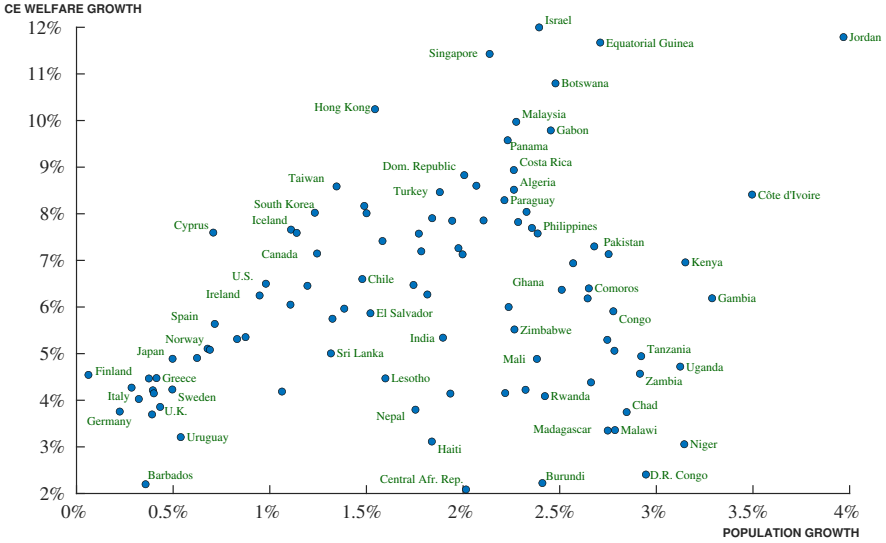
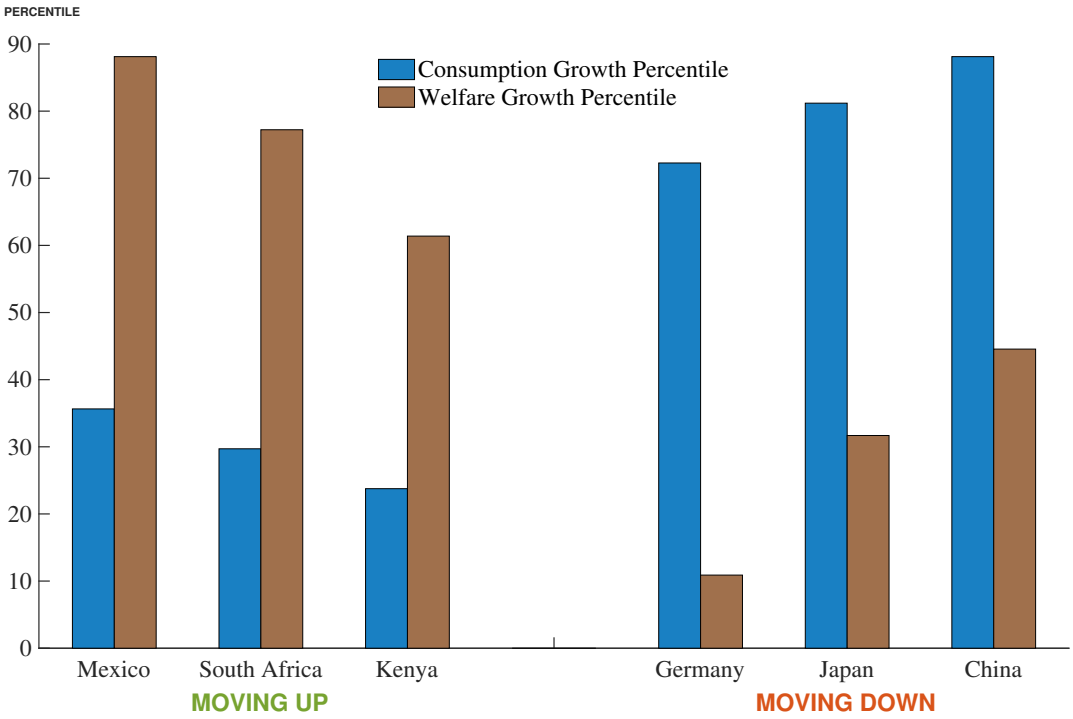
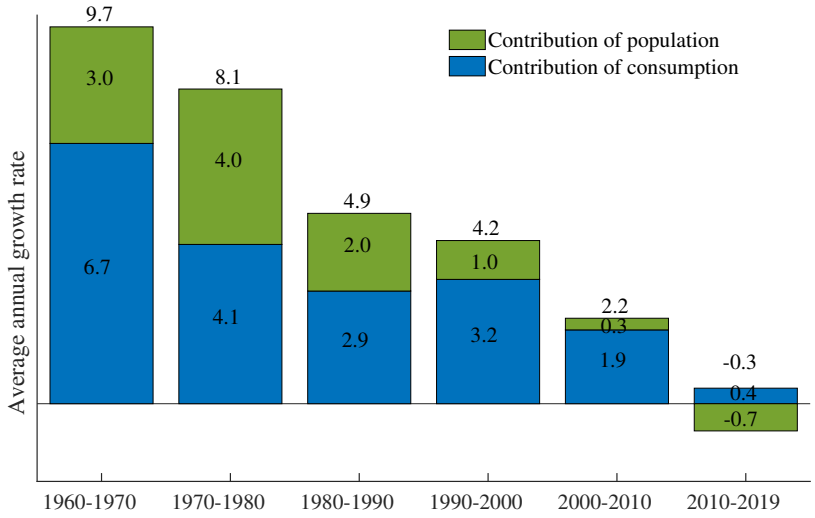


Figure 6: Changing Perspectives on Who is Growing Rapidly




Notes: The chart shows the percentile in the cross-country distribution of growth rates between 1960 and 2019 for a select set of countries. Data is from the Penn World Tables 10.0.

Figure 7: Growth in Japan by Decade




Notes: The numbers in the bars are CE welfare growth, the percentage point contribution from population growth, and per capita consumption growth.

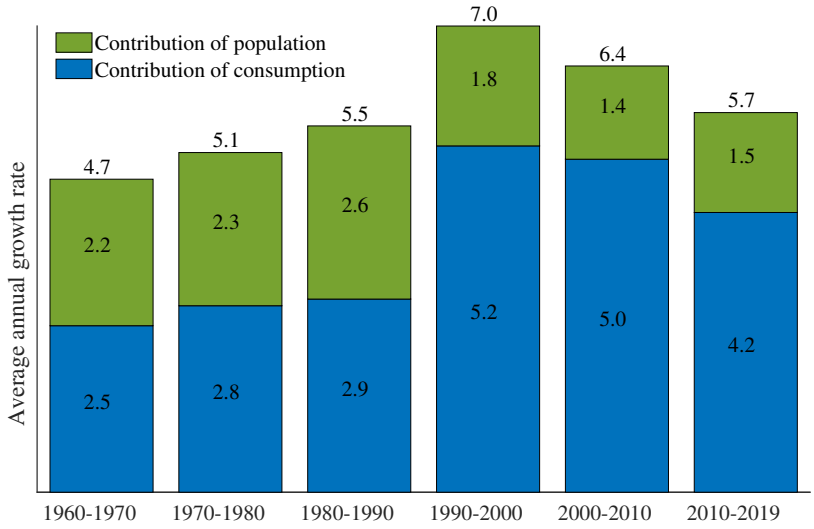
In constrast, a number of countries with slow consumption growth move up sharply in the distribution. Mexico rises from the 35th percentile to the 88th, and Kenya rises from the 23rd percentile to the 61st.

## 3.2 Growth Rates in Sub-Periods

Figure 7 shows CE welfare growth in Japan by decade since 1960. The well-known slowdown in Japanese growth is evident in the blue bars, which show consumption growth. But this slowdown is reinforced by declining rates of population growth. Overall CE welfare growth slows from 9.7% per year in the 1960s to -0.3% per year in the 2010s. For this most recent decade, a negative population growth rate of -0.15% per year — when scaled up by $v(c)$ — more than offsets the modest consumption growth rate of 0.4%.

Figure 8 shows growth in China since the 1960s. Population growth in China (not shown) slows from 2.3% per year in the 1960s to just 0.5% per year in the 2010s. However, the rising value of life $v(c_t)$ to some extent offsets this decline: the contri-

Figure 8: Growth in China by Decade




Notes: The numbers in the bars are CE welfare growth, the percentage point contribution from population growth, and per capita consumption growth.

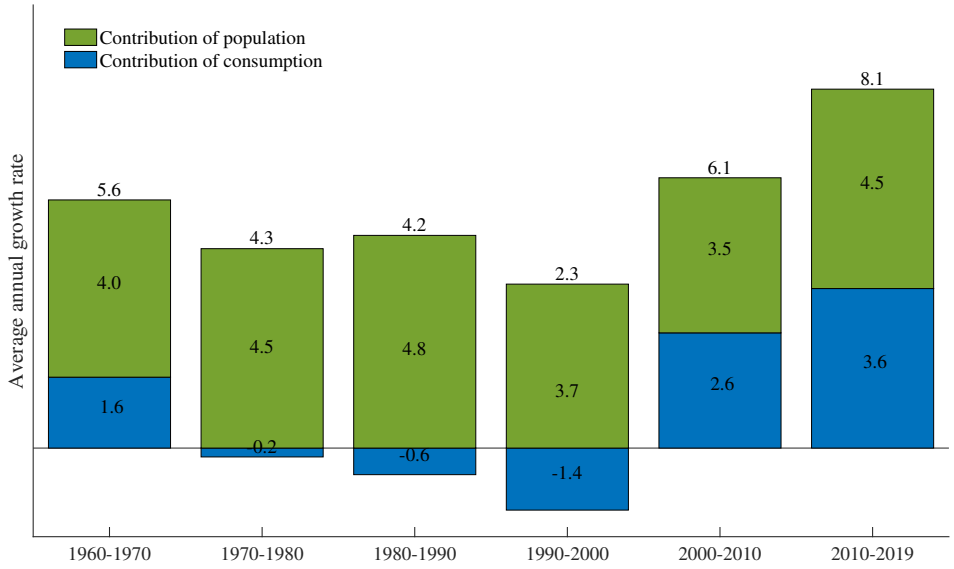
bution of population growth to CE welfare growth falls from just 2.2% per year in the 1960s to 1.5% per year in the 2010s. CE welfare growth has slowed since the 1990s, but the decline is modest, from 7.0% per year to 5.7% per year.

In contrast, the bulk of CE welfare growth in Sub-Saharan Africa since the 1960s has been due to population growth, as shown in Figure 9. Population growth was relatively stable at just over 2.5% per year during the entire period, and the population term accounts for around 4pp of CE welfare growth in Sub-Saharan Africa each decade. Consumption growth rose in the 2000s and 2010s, leading to a robust CE welfare growth rate of more than 8% in the 2010s.

## 3.3 Growth over the Very Long Run

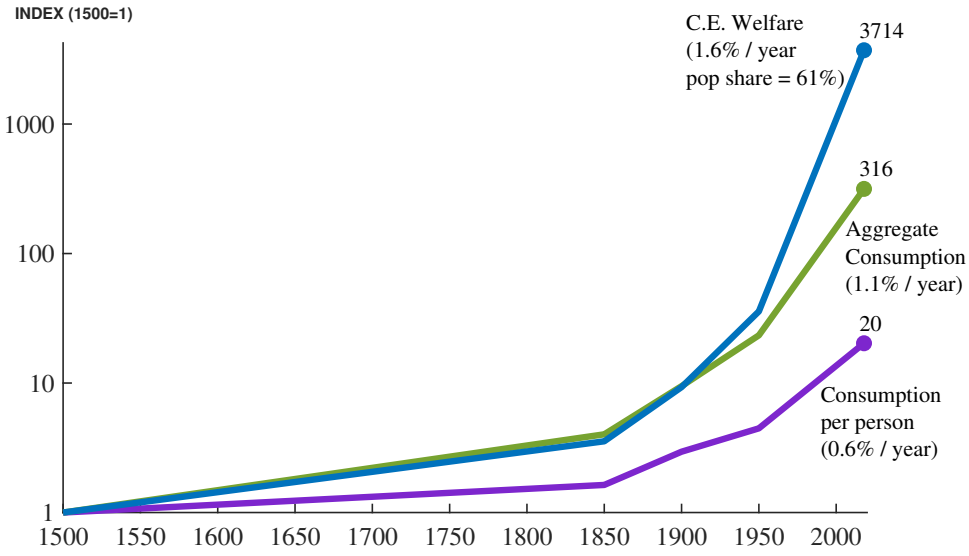
Figure 10 shows the gain in CE welfare for the world as a whole since 1500 using data from The Maddison Project (de Pleijt and van Zanden, 2020). Over more than five centuries, consumption per person rises by a factor of 20, corresponding to average growth of 0.6% per year. Population growth is similarly modest at just 0.5% per year,

Figure 9: Growth in Sub-Saharan Africa by Decade




Notes: The numbers in the bars are CE welfare growth, the percentage point contribution from population growth, and per capita consumption growth.

Figure 10: Cumulative Growth in "The World," 1500–2018




Note: Data from The Maddison Project data of de Pleijt and van Zanden (2020). We estimate consumption as 0.8 times per capita GDP for this figure.

but the cumulative effect on welfare is stunningly different: CE welfare rises by a factor of 3,700 versus the 20-fold increase in per capita consumption. The average annual growth rate of CE welfare is just a percentage point higher, at 1.6% per year instead of 0.6% per year, but such is the power of compounding for 500 years.

# 4. Robustness

In this section we first explore robustness of the results above with respect to our baseline parameter choices for preferences. These parameters dictate the valuation of life and, hence, the importance of population growth for welfare. We then examine how our country-by-country results are affected by allowing for within-country heterogeneity in consumption and by considering alternative treatments of population changes reflecting cross-country migration. Finally, we examine the respective contributions of fertility and longevity to population growth.

## 4.1 Parameters governing the value of life

Table 3 shows the sensitivity of CE welfare growth, on average and in select countries, to alternative calibrations of parameters dictating the value of life. We report per capita consumption in the first row to highlight the contribution of population across different specifications. As we move away from the baseline calibration, we impose a lower bound of 1 on $v(c)$, consistent with Rosen (1988). Comparing the second and third row shows that this makes little difference for the baseline calculation, except for Ethiopia where the lower bound of 1 binds for most years.

**Calibration of $\bar{u}$.** In our baseline calculation, we target $v(c) = 4.87$ in the U.S. in 2006 (U.S. Environmental Protection Agency, 2020). With the log specification, this implies $v(c)$ values in developing countries that are consistent with the range of values employed by the World Health Organization to determine the cost effectiveness of spending to reduce mortality (WHO, 2001).

Table 3: CE welfare growth for Different Parameter Values, 1960–2019

| | Mean | U.S. | Japan | Mexico | Ethiopia |
|---|---|---|---|---|---|
| 1. Per capita consumption | 2.8% | 2.2% | 3.2% | 1.8% | 2.5% |
| 2. Baseline | 5.9% | 6.5% | 4.9% | 8.6% | 4.4% |
| 3. Baseline ($v \geq 1$) | 6.0% | 6.5% | 4.9% | 8.6% | 5.2% |
| 4. VSL $_{US,\ 2006}$ 50% lower ($v \geq 1$) | 4.5% | 4.1% | 3.8% | 4.0% | 5.1% |
| 5. VSL $_{US,\ 2006}$ 50% higher ($v \geq 1$) | 9.8% | 8.9% | 6.1% | 13.6% | 10.9% |
| 6. $\gamma = 2$ ($v \geq 1$) | 4.6% | 5.1% | 3.7% | 3.8% | 5.1% |
| 7. Constant $v = 4.87$ ($\gamma = 0.79$) | 10.6% | 7.0% | 5.7% | 11.8% | 15.4% |
| 8. Constant $v = 2.7$ ($\gamma = 0.63$) | 7.1% | 4.8% | 4.6% | 7.4% | 9.7% |
| 9. Constant $v = 1$ ($\gamma = 0$) | 4.4% | 3.2% | 3.7% | 3.8% | 5.1% |

Notes: The table reports average annual growth rates for different CE welfare measures. "Mean" refers to the population-weighted mean across countries. Given the $c_{us,2006} = 1$ normalization, $v(c_{us,2006}) = \bar{u}$ for each of our robustness checks. Baseline corresponds to $\gamma = 1$, $\bar{u} = 4.87$, and variable $v(c)$.

Our welfare accounting for population growth is clearly sensitive to the assumed value of a statistical life (VSL). Therefore, we consider alternative calibrations targeting a VSL that is either half the baseline, requiring $\bar{u} = 2.4$, or 50% higher, with $\bar{u} = 7.3$. For comparison the U.S. Department of Transportation (2014), based on a broad review of the literature, suggests that safety regulations should be evaluated using VSL's over a range of $4 to $10 million for the U.S. in 2001. The range we consider maps to a VSL of $2.8 to $8.6 million for 2001, so slightly conservative relative to the DOT's recommendations.

The results of these robustness checks are in the fourth and fifth rows of Table 3. As anticipated, CE welfare growth is higher the larger is the value of $\bar{u}$. But even when we calibrate to the low VSL of $2.8 million for the U.S. in 2001 — corresponding to $\bar{u} = 2.4$ — population contributes 38% of CE welfare growth on average.

**Calibration of $\gamma$.** Our baseline calculation uses a log utility function in consumption. We consider the sensitivity of our results to alternative CRRA functions:

$$u(c) = \bar{u} + \frac{c^{1-\gamma} - 1}{1-\gamma} \implies v(c) = \left(\bar{u} - \frac{1}{1-\gamma}\right) c^{\gamma-1} + \frac{1}{1-\gamma}\,. \tag{4}$$

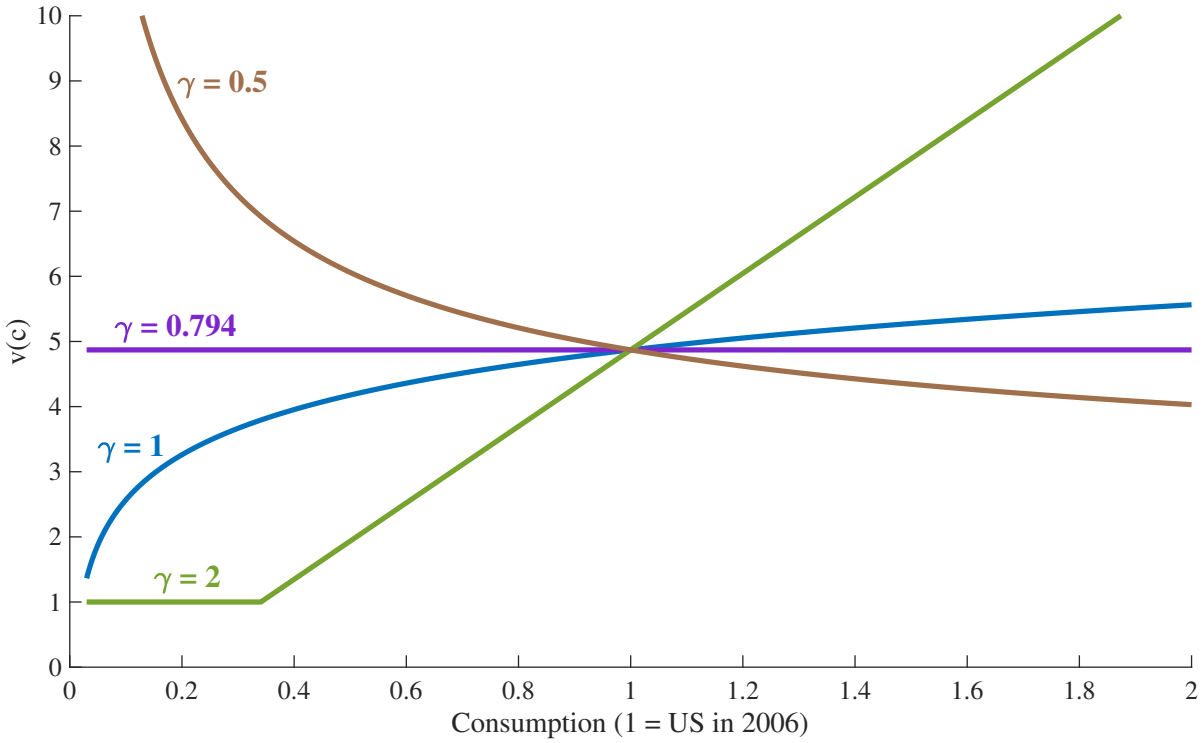
Note that $v(c)$ is a function of $\gamma$; so, while the U.S. value for $v(c)$ in 2006 is calibrated independently of $\gamma$, how $v(c)$ evolves over time and across countries depends on $\gamma$.

Figure 11 illustrates how $v(c)$ varies with consumption for several values of $\gamma$. The figure makes clear that, relative to $\gamma = 1$, higher $\gamma$'s yield lower values for $v(c)$ in the past and for countries poorer than the U.S. Therefore it implies a lower weight on population growth for our sample period. But note that higher $\gamma$'s also imply that population growth should become even more important going forward as countries get richer.

Turning back to Table 3, the sixth row shows the results of our calculation with $\gamma = 2$. The share of CE welfare growth reflecting population growth is 40% on average, weighting countries by their populations, compared to 53% in our baseline calculation. Thus population growth remains important.

The final rows of Table 3 consider three cases where $v(c)$ is constant. From equation (4), $v(c)$ being independent of $c$ requires parameters $\gamma$ and $\bar{u}$ be related: $\gamma = 1 - \frac{1}{\bar{u}}$; in turn implying $v(c) = \bar{u}$. Row 7 assumes constant $v = 4.87$, corresponding to our calibrated target for the U.S. in 2006; row 8 assumes $v = 2.7$, corresponding to the average $v$ across country-years in our baseline calculation; and row 9 assumes $v = 1$. For $v = 1$, CE welfare growth simply equals aggregate consumption growth. The first case generates much more growth in CE welfare, as it raises $v(c)$ in all country-years to be that of the U.S. in 2006. The second case generates the average welfare growth close to that from our baseline. But it also generates larger differences in the growth rates across countries: CE welfare growth is slower in the U.S., Japan, and Mexico but faster in Ethiopia. The final row shows that, even in the extreme case where consumption-equivalent welfare growth is simply equal to aggregate consumption growth ($v = 1$, $\gamma = 0$), population growth contributes 36% of all growth.

Figure 11: $v(c)$ for different values of $\gamma$




Notes: Different $v(c)$ are shown for different values of $\gamma$, but all curves are calibrated to match the U.S. value of life in 2006 at $c = 1$; that is, all have $\bar{u} = 4.87$.

## 4.2 Heterogeneity and Inequality

The framework from Section 2 assumes a representative agent within each country. However, heterogeneity could be important. For example, what if population growth occurs disproportionately among the poor so that a value of life based on average consumption overstates the value of adding people? In this section, we incorporate consumption inequality.

Consider an economy of $N_t$ individuals who potentially differ in their consumption. The total expected flow of welfare (from behind the veil of ignorance) enjoyed by this economy is:

$$\begin{aligned} W_t &= \mathbb{E}_t \sum_{i=1}^{N_t} u(c_{it}) \\ &= N_t \cdot \mathbb{E}_t u(c_{it}) \end{aligned}$$

where the expectation is taken across people alive at date $t$.

We derive consumption-equivalent welfare (CEW) growth assuming log utility and a log-normal distribution of consumption across individuals. That is, we assume:

$$u(c_{it}) = \widetilde{u} + \log c_{it}, \text{ where } \log c_{it} \overset{\text{i.i.d.}}{\sim} \mathcal{N}\left(\log c_t\,,\, \sigma_t^2\right),$$

which then implies:

$$\mathbb{E}u(c_{it}) = \widetilde{u} + \log c_t - \frac{1}{2} \cdot \sigma_t^2.$$

Consumption-equivalent welfare growth is then given by:

$$g_{\lambda_t} = \left(\widetilde{u} + \log c_t - \frac{1}{2} \cdot \sigma_t^2\right) \cdot g_{N_t} + g_{c_t} - \sigma_t \cdot g_{\sigma_t}. \tag{5}$$

To illustrate the generality of equation (5) versus baseline equation (3), consider a scenario where births in country A skew towards lower-income households acting, ceteris paribus, to lower consumption growth and raise consumption inequality.

Equation (3) captures its impact on growth in A's average consumption, while equation (6) also captures any impact through consumption inequality.

Our calibration above for $\bar{u}$ was based on an average VSL in the U.S. for 2006. With inequality, those estimates for VSL, and in turn $\bar{u}$, should be interpreted to reflect both the mean and dispersion in consumption in the U.S. in 2006. This implies $\widetilde{u}$ and $\bar{u}$ are related by $\widetilde{u} = \bar{u} + \frac{1}{2}\sigma^2_{US,2006}$. Substituting this expression into the preceding equation gives:

$$g_{\lambda_t} \;=\; \left(v(c_t) - \frac{1}{2}\cdot\left(\sigma_t^2 - \sigma^2_{\text{US, 2006}}\right)\right)\cdot g_{N_t} \;+\; g_{c_t} \;-\; \sigma_t \cdot g_{\sigma_t}, \tag{6}$$

where $v(c_t) \;=\; \bar{u} + \log c_t$ is the value of life based on average consumption used earlier.

Equation (6) highlights two ways in which introducing within-country heterogeneity changes our calculation. First, due to consumption heterogeneity and the concavity in $u(c)$, the weight on population growth is modified. For example, relative to our baseline, the weight is lower for country-years with greater consumption inequality than the U.S. in 2006. Second, there is an additional term through which increases in consumption inequality reduce CEW growth.

We implement this inequality-adjusted calculation in Table 4 for a sample of 90 countries between 1980 and 2007.[7] Overall, taking into account within-country heterogeneity lowers consumption-equivalent welfare growth by 10 basis points, from 6.1% to 6.0%, with an average absolute adjustment of 20 basis points. For some countries, the adjustment is sizable: our baseline methodology understates welfare growth in Brazil because of the falling inequality over this period, but overstates growth in South Africa, which has greater inequality than the U.S in 2006.

### 4.3 Taking Migration into Account

Our calculations to this point credit countries for the growth in the number and standard of living of its resident populations. This makes no distinction based on where the individuals were born and consequently assigns the contribution of mi-

[7] Data on consumption inequality in each of these countries are from Jones and Klenow (2016).

Table 4: Baseline vs Inequality-Adjusted CE welfare growth, 1980–2007

| | Baseline | Inequality Adjusted | Adjustment |
|---|---|---|---|
| Ethiopia | 2.1% | 2.4% | + 0.27% |
| Brazil | 7.1% | 7.3% | + 0.15% |
| Mexico | 7.0% | 7.0% | - 0.06% |
| Japan | 4.1% | 4.0% | - 0.10% |
| China | 6.7% | 6.6% | - 0.15% |
| United States | 7.1% | 6.9% | - 0.21% |
| India | 5.8% | 5.6% | - 0.29 % |
| Germany | 2.4% | 2.1% | - 0.29 % |
| South Africa | 7.7% | 6.8% | - 0.83 % |
| All countries – pop. weighted | 6.1% | 6.0% | - 0.14% |
| Mean absolute deviation | | | 0.22% |

Notes: The table reports average consumption equivalent welfare growth using our baseline framework (equation 3) and adjusting for inequality (equation 6).

grants to their destination country. Taking the other extreme, one might instead attribute people to the country in which they are born. Compared to our baseline calculation, we can add flow utility for out-migrants and subtract flow utility from in-migrants:[8]

$$W_{it} = N_{it} \cdot u(c_{it}) + \sum_{j \neq i} N_{i \to j,t} \cdot u(c_{jt}) - \sum_{j \neq i} N_{j \to i,t} \cdot u(c_{it}),$$

where $N_{i \to j,t}$ is the population born in country $i$ and living in country $j$ in year $t$ and $N_{j \to i,t}$ is the population born in country $j$ living in country $i$ in year $t$.

[8] An intermediate treatment would be to give countries credit for the higher consumption enjoyed by in-migrants from poorer countries.

Growth in country welfare adjusted for migration is then

$$\begin{aligned} g_{\lambda_{it}} = \; & v(c_{it}) \cdot g_{N_{it}} \; + \; g_{c_{it}} \\ & + \sum_{j \neq i} \frac{N_{i \to j,t}}{N_{it}} \cdot \frac{u(c_{jt})}{u(c_{it})} \left( v(c_{it}) \cdot g_{N_{i \to j,t}} + \frac{v(c_{it})}{v(c_{jt})} \cdot g_{c_{jt}} \right) \\ & - \sum_{j \neq i} \frac{N_{j \to i,t}}{N_{it}} \left( v(c_{it}) \cdot g_{N_{j \to i,t}} + g_{c_{it}} \right). \end{aligned} \tag{7}$$

The first term is our baseline, which credits all immigrants to the *destination* country. The second term adds in growth from out-migrants, and the third term subtracts growth from in-migrants. This adjusted measure therefore credits migrants to the *source* country.

To implement this migration adjustment, we use data from the World Bank's Global Bilateral Migration Database that reports the shares of each country's resident population by their country of origin for select years (1960, 1970, 1980, 1990, and 2000). Using this data, we can adjust for migration for 81 countries.

Figure 12 plots migration-adjusted welfare growth vs. our baseline welfare growth for the 81 countries from 1960 to 2000. The points are close to the 45 degree line as results with and without the migration adjustment are highly correlated at 0.92. While the adjustments are sizable for certain countries, it does not alter the important role for welfare growth assigned to population growth. Figure 13 shows a set of countries for which the adjustment particularly raises welfare growth due to high net in-migration or lowers it due to high net out-migration.

### 4.4 Roles of Birth and Death Rates

From Table 1, population growth contributed CEW growth of about 3pp per year, weighting countries by population. That population growth reflects rates both of countries' births and deaths. Prior papers have quantified the importance of rising longevity for welfare, including Nordhaus (2003), Becker, Philipson, and Soares (2005), Murphy and Topel (2006), Hall and Jones (2007), and Jones and Klenow (2016). For instance, Jones and Klenow attribute consumption-equivalent growth

Figure 12: Baseline vs. Migration-Adjusted CEW growth

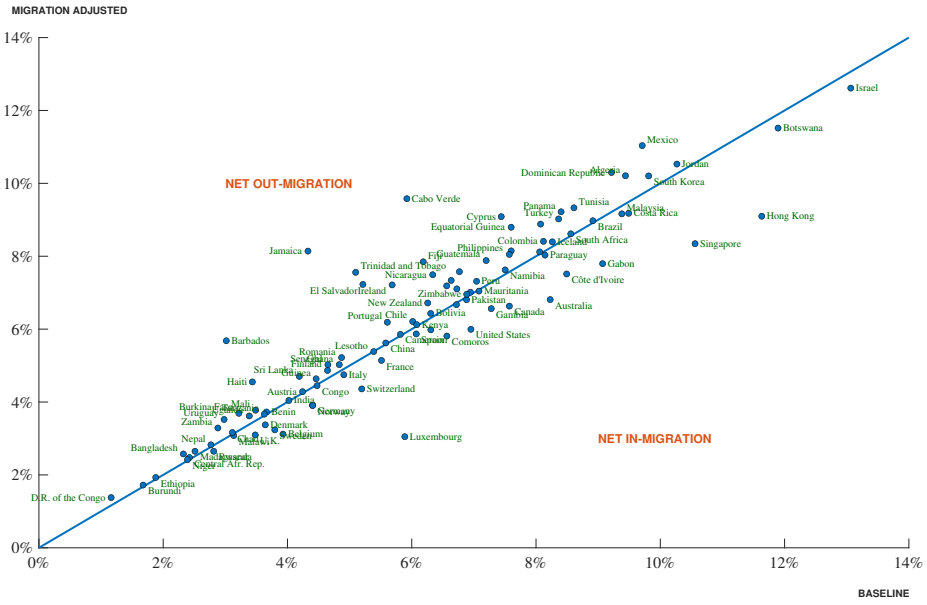
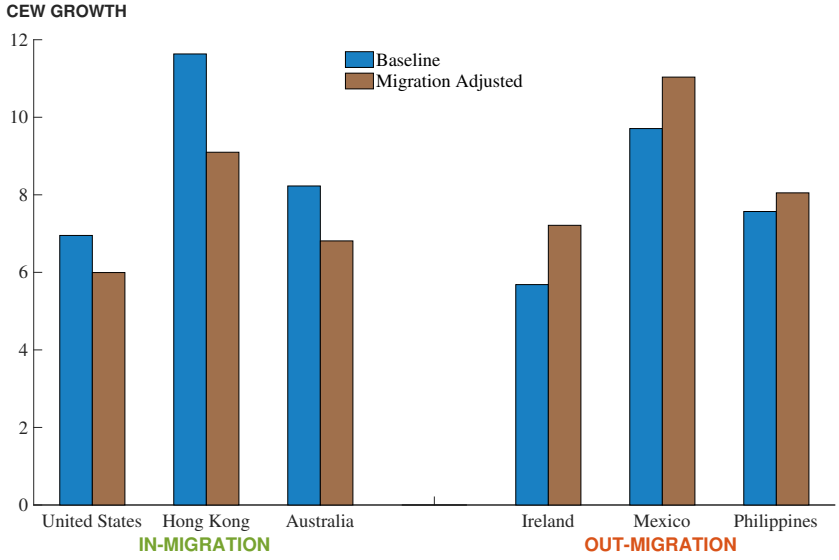



Figure 13: Countries with Large Migration Adjustments




The chart shows key countries for which the migration adjustment is large.

of nearly one percent per year to rising longevity for a sample of 128 countries for 1980 to 2007. That sample differs considerably from ours in terms of countries and time period considered. But comparing their 1 percent growth rate, ascribed purely to rising longevity, to our 3 percent suggests that increases in the number of persons living a life has contributed even more to welfare growth than has increased longevity.

To examine this in more depth, in the Online Appendix we compare countries' actual rates of population growth to counterfactual rates had each experienced no decline in death rates by age over the sample period. We construct these counterfactuals for 24 of our countries with data on birth and death rates from the Human Mortality Database combined with that on net migration from the World Bank's Global Bilateral Migration Database. The appendix provides details on the calculation.

In Table 5 we report the actual versus fixed-longevity rates of population growth aggregating the 24 countries by their populations. Fixing longevity reduces population growth from 0.72% to 0.53%. So nearly three-quarters of population growth for these countries reflected increases in the number of lives lived; that suggests it also contributed the lion's share of welfare growth we attribute to population growth. Table 5 also details the calculation for the five countries France, United Kingdom, Italy, Japan, and the United States. (Results for all 24 countries are in the online appendix.) Italy and Japan are clear outliers among the 24 countries, with declining longevity explaining about three quarters of population growth for each.

## 5. Beyond Consumption

One limitation of our baseline approach is that it only incorporates consumption in flow utility. For example, parents have kids because they presumably enter their utility function, but this is absent from our baseline. In addition, over time parents may have increasingly made a "quantity-quality" tradeoff, choosing fewer kids, but investing more in each.

Table 5: Population Growth Holding Longevity Constant

| Select countries | $g_N$ | Counterfactual $g_N$ |
|---|---|---|
| France | 0.61% | 0.42% |
| UK | 0.41% | 0.25% |
| Italy | 0.33% | 0.08% |
| Japan | 0.51% | 0.15% |
| USA | 1.03% | 0.89% |
| All countries – pop. weighted | 0.72% | 0.53% |

We therefore extend our framework in this section to incorporate parental fertility decisions that trade off altruism toward their kids (their consumption and human capital) with their own parental consumption and leisure time.[9]

## 5.1 Framework

Suppose total flow welfare takes the form:

$$W(N_t^p,\, N_t^k,\, c_t^p,\, l_t,\, c_t^k,\, h_t^k,\, b_t) \;=\; N_t^p \cdot u(c_t^p,\, l_t,\, c_t^k,\, h_t^k,\, b_t) + N_t^k \cdot \widetilde{u}(c_t^k),$$

where $N^p$ is the number of adults ("$p$" for parents), $N^k$ is the number of children ("$k$" for kids), $b$ is number of children per adult, $c^p$ is adult consumption, $l$ is adult leisure, $c^k$ is consumption per child, and $h^k$ is human capital per child. Total population satisfies $N = N^p + N^k = (1+b) \cdot N^p$.

Aggregate flow welfare is the sum of all parents' flow welfare (from their own consumption, their own leisure, their kids' consumption during childhood, their kids' human capital, and the number of kids per parent) and all kids' flow welfare. The fact that the consumption, human capital, and number of kids affect parental utility is reminiscent of Barro and Becker (1989) and Farhi and Werning

[9] If individuals prefer living in more dense, or in less dense, locations then that provides an added channel for population growth to affect welfare, as population growth affects density. While we do not incorporate this channel, hedonic estimates typically find density to be a positive attribute as real wages are decreasing in density, ceterus paribus. (Nominal wages increase with density, but not as much as the cost of living.) See Ahlfeldt and Pietrostefani (2019) for a review of estimates. So including that estimated effect would actually add to population growth's estimated impact on welfare growth.

(2007); something like this is necessary to explain why parents have kids and invest resources in them.

We make kids' flow welfare a function of their consumption only. We have in mind that kids' leisure is fixed at one, so it is suppressed, and that kids will enjoy the benefits of their human capital in the form of higher consumption when they are themselves adults.

To calculate consumption-equivalent welfare growth, we ask by what factor $\lambda_t$ one would have to scale up both parents' and kids' consumption at $t$ to match the flow utility at $t + dt$ given the changing numbers of parents and kids and changing per capita variables:

$$W(N_t^p, N_t^k, \lambda_t c_t^p, l_t, \lambda_t c_t^k, h_t^k, b_t) = W(N_{t+dt}^p, N_{t+dt}^k, c_{t+dt}^p, l_{t+dt}, c_{t+dt}^k, h_{t+dt}^k, b_{t+dt}).$$

Appendix A.3 shows that growth in consumption-equivalent welfare is:

$$\begin{aligned} g_{\lambda_t} = \kappa_t \Bigg[ \omega_t^p \left( \frac{dN_t^P}{N_t^P} + \frac{u_{c_t^p} c_t^p}{u_t} \frac{dc_t^p}{c_t^p} + \frac{u_{lt} l_t}{u_t} \frac{dl_t}{l_t} + \frac{u_{c^k t} c_t^k}{u_t} \frac{dc_t^k}{c_t^k} + \frac{u_{h^k t} h_t^k}{u_t} \frac{dh_t^k}{h_t^k} + \frac{u_{bt} b_t}{u_t} \frac{db_t}{b_t} \right) \\ + \omega_t^k \left( \frac{dN_t^K}{N_t^K} + \frac{\tilde{u}'(c_t^k) c_t^k}{\tilde{u}(c_t^k)} \frac{dc_t^k}{c_t^k} \right) \Bigg], \end{aligned} \tag{8}$$

where $\omega_t^p$ and $\omega_t^k$ are the total welfare shares of parents and kids in year $t$, and $\kappa_t$ puts this expression in consumption equivalent units.

In our framework, parental decisions are privately optimal. Once we pick functional forms and calibrate parameters, optimality conditions from parents' utility maximization problem will allow us to express the weights on each growth rate above in terms of observables. Specifically, we assume that parents at each date

solve the following problem:

$$\begin{aligned} \max_{c^p,\, l,\, c^k,\, h^k,\, b} \quad & u(c_t^p,\ l_t,\ c_t^k,\ h_t^k,\ b_t) \\ \text{subject to:} \quad & c_t^p + b_t \cdot c_t^k \leq w_t \cdot h_t \cdot l_{c_t} \\ & h_t^k = f(h_t \cdot e_t) \\ & \text{and } \ l_{c_t} + l_t + b_t \cdot e_t \leq 1 \end{aligned}$$

where $w$ is the real wage per unit of human capital, $h$ is parental human capital, $h^k$ is kids' human capital, $l_c$ are parental hours worked, and $e$ is parental time investment per child. Parents spend their earnings on their own consumption and their kids' consumption. Kids' human capital is an increasing function of their parents' human capital and their parents' time investment in them. Parents have a unit of time to allocate across work, leisure, and time with their kids.

To make progress, we assume these specific functional forms for parents' and kids' flow utility, respectively:

**Assumption 1:** $u(c_t^p,\ l_t,\ c_t^k,\ h_t^k,\ b_t) = \log(c_t^p) + \alpha b_t^\theta \cdot \log(c_t^k) + \tilde{f}(l_t, h_t^k, b_t)$

**Assumption 2:** $\widetilde{u}(c^k) = \bar{u}_k + \log(c_t^k)$

where $\tilde{f}(\ell_t, h_t^k, b_t)$ is a concave increasing function. In Assumption 1, $\alpha > 0$ and $\theta > 0$ are parameters governing parental altruism towards their kids. In the special case where $\alpha = 1$ and $\theta = 1$ parents are total utilitarians with respect to their own family. The literature often considers cases with $\alpha < 1$ and $\theta < 1$ (Doepke and Tertilt, 2016).

With these functional forms, growth in consumption-equivalent welfare is:

$$
\begin{aligned}
g_{\lambda_t} \;&= \pi_t^p \cdot v\left(c_t^p, c_t^k, \vec{x}_t\right) \cdot g_{N_t^p} \;+\; \pi_t^k \cdot \tilde{v}(c_t^k) \cdot g_{N_t^k} && \text{Population} \\
&+ \pi_t^p \cdot g_{c_t^p} \;+\; (1-\pi_t^p) \cdot g_{c_t^k} && \text{Consumption} \\
&+ \pi_t^p \cdot \frac{u_{lt}\, l_t}{u_{c^p t}\, c_t^p} \cdot g_{l_t} && \text{Leisure} \\
&+ \pi_t^p \cdot \frac{u_{bt}\, b_t}{u_{c^p t}\, c_t^p} \cdot g_{b_t} && \text{Quantity of kids} \\
&+ \pi_t^p \cdot \frac{u_{h^k t}\, h_t^k}{u_{c^p t}\, c_t^p} \cdot g_{h_t^k} && \text{Quality of kids}
\end{aligned}
$$

where

$$
\pi_t^p = \frac{N_t^p}{(1+\alpha b_t^\theta) N_t^p + N_t^k} \quad ; \quad \pi_t^k = \frac{N_t^k}{(1+\alpha b_t^\theta) N_t^p + N_t^k} \quad ;
$$

$$
v\left(c_t^p, c_t^k, \vec{x}_t\right) = v\left(c_t^p, l_t, c_t^k, h_t^k, b_t\right) = \frac{u\left(c_t^p, l_t, c_t^k, h_t^k, b_t\right)}{u_c^p\left(c_t^p, l_t, c_t^k, h_t^k, b_t\right) \cdot c_t^p} \quad ; \quad \tilde{v}(c_t^k) = \frac{\tilde{u}(c_t^k)}{\tilde{u}'(c_t^k) \cdot c_t^k}.
$$

The first line in the CEW growth expression is the new version of the "population growth" term. This population term differs from the simple $g_N \cdot v(c)$ specification in previous sections for several reasons. First, parents' value of a year of life $v$ and kids' value of a year of life $\widetilde{v}$ may differ. Second, the value of a year of life for parents depends on not only their own consumption but also on their kids' consumption, their own leisure, their own fertility, and their kids' human capital. Third, we have a scaling factor of less than one in front of each of these terms. The intuition for this is that the $\lambda$ factor enters three times rather than just twice: once for the parents, once for the kids, and then once because the parents themselves care about their kids' consumption (the $\alpha b_t^\theta$ term). Because consumption matters through multiple channels, its growth becomes more heavily weighted vis-a-vis population growth.

The remaining lines in the CEW growth expression are the new version of the "per capita growth" term. It now includes growth in leisure, kids' human capital, and fertility along with growth in consumption per parent and per kid. Note that the weight on parent terms $\pi_p$ is *less than* the share of parents in the population, and the corresponding weight on kids' consumption growth $1-\pi_p$ exceed the share of kids in the population. This likewise reflects parental altruism, which results in

"double counting" (upweighting) the growth of kids' consumption. This point was emphasized by Caplin and Leahy (2004) and Farhi and Werning (2007).

**Illustrative example.** A special case of this growth accounting is helpful for intuition. Suppose $\alpha = 1$ and $\theta = 1$, parents are total utilitarians for their own family, which implies $dc^k/c^k = dc^p/c^p$. Secondly, evaluate growth at a point where the value of a year of life happens to be the same for parents and kids, $\widetilde{v}(c_t^k) = v(c_t^p, \vec{x}_t) = v(c_t)$. Then CEW growth becomes

$$\begin{aligned} g_{\lambda_t} \;=\; & g_{c_t} + \frac{N_t^p + N_t^k}{N_t^p + 2N_t^k} \cdot v(c_t) \cdot g_{N_t} \\ & + \frac{N_t^p}{N_t^p + 2N_t^k} \cdot \left( \frac{u_{lt} l_t}{u_{ct} c_t} \cdot g_{l_t} + \frac{u_{bt} b_t}{u_{ct} c_t} \cdot g_{b_t} + \frac{u_{h^k t} h_t^k}{u_{ct} c_t} \cdot g_{h_t^k} \right). \end{aligned}$$

Note the 2 appearing in the denominators on all terms other than consumption growth. The double counting of kids' consumption (their own utility and their parents' utility from it) downweights all non-consumption terms: we need to scale up consumption by a smaller amount to match the value of more people, leisure, etc.

## 5.2 Implementation

We use parents' first order conditions to map weights in the growth accounting to observables. Specifically,

$$FOC(l_t): \quad \frac{u_{lt} l_t}{u_{c^p t} c_t^p} = \frac{w_t h_t l_t}{c_t^p}, \tag{9}$$

$$FOC(b_t): \quad \frac{u_{bt} b_t}{u_{c^p t} c_t^p} = b_t \frac{(c_t^k + w_t h_t e_t)}{c_t^p}, \tag{10}$$

$$FOC(h_t^k): \quad \frac{u_{h^k t} h_t^k}{u_{c^p t} c_t^p} = b_t \frac{1}{\eta_t} \frac{w_t h_t e_t}{c_t^p}, \text{ where } \eta_t = \frac{f'(h_t e_t) h_t e_t}{f(h_t e_t)}. \tag{11}$$

Equation (9) says that that the weight on leisure growth should be tied to the marginal rate of substitution between consumption and leisure, which in turn equals earnings relative to consumption. Equation (10) connects the weight on fertility growth to the marginal rate of substitution between fertility and consumption. The

latter can be assessed using total spending on kids (including foregone earnings due to time spent investing in kids' human capital) relative to adult consumption. Equation (11) indicates that the weight on human capital growth is related to the marginal rate of substitution between human capital and consumption, which equals implicit spending on kids' human capital relative to adult consumption.

**Calibration.** The weight given to a child's human capital growth partly reflects the elasticity of a child's human capital with respect to parental input: $\eta_t = \frac{f'(h_t e_t) h_t e_t}{f(h_t e_t)}$. We impose a constant $\eta$. To calibrate $\eta$ we exploit that $h_t^k$'s elasticity with respect to $h_t e_t$ is the same as for $h_t$ alone. We base that elasticity on Mincer-equation estimates by Lee, Roys and Seshadri (2015), who include schooling of a respondent's parents, as well as the respondent's, as predictors of the respondent's wage. Assuming that (i) the respondent's schooling coefficient proxies for the impact of parental schooling on the parents' own human capital, and (ii) that parents' choice of $e_t$ is orthogonal to their schooling, then $\eta$ is identified by the estimated impact of parental schooling on the respondent's wage relative to the impact of their own. This ratio, summing the impacts of both parents' schooling, equals 0.24 (=.0142/.0591).

To calibrate the parameters governing parental altruism towards their kids, $\alpha$ and $\theta$, we rely on a USDA study (Lino, 2011) of spending on kids versus parents within households. Note that, under Assumptions 1 and 2, the first-order conditions from the parents' utility maximization problem imply:

$$\frac{c_t^k}{c_t^p} = \alpha b_t^{\theta - 1}.$$

For example, for $\theta = 1$ and $\alpha = 1$ parents equate each kid's consumption to their own. From Lino (2011), households with two parents and two children, for whom $b = 1$, spend approximately two-thirds as much on the children as the parents. From this we calibrate $\alpha = 2/3$. By contrast, two-parent household with one child spend somewhat more *per* child; those with three children spend somewhat less. These patterns are consistent with a value for $\theta$ of about $0.8$. We treat this as a baseline while considering robustness to $\theta = .6$ and $\theta = 1$.

As in previous sections, we target $v(c_t^p, c_t^k, \vec{x}_t) = 4.87$ for the U.S. in 2006. To calibrate $\tilde{v}(c_t^k)$, we assume $\tilde{v}(c_t^k) = v(c_t^p, c_t^k, \vec{x}_t)$ in the U.S. in 2006. Given additively separable preferences, this implies equal utility flows for parents and their children in the U.S. at that time. We consider robustness to $\tilde{v}(c_t^k)/v(c_t^p, c_t^k, \vec{x}_t) = 0.8$ or $1.2$ for the U.S. in 2006.

We employ welfare accounting to benchmark other countries' levels for $v(c_t^p, c_t^k, \vec{x}_t)$ and $\tilde{v}(c_t^k)$. We chain welfare in the country with the second-highest level of per capita consumption in 2006, the Netherlands, to that with the highest, the United States, based on their differences in consumption, leisure, number of children, and children's human capital. In the same way, we proceed to link the third richest, Japan, to the Netherlands, and so forth. We then chain $v(c_t^p, c_t^k, \vec{x}_t)$ and $\tilde{v}(c_t^k)$ through time within countries to reflect the growth rates in each of their arguments.[10]

**Data.** As in previous sections, consumption and total population are from the Penn World Table 10.0. The total number of children (0-19 years old) is from the World Bank. We combine data on total hours worked (Penn World Table) and on working age population (World Bank) to calculate hours worked per adult. We measure parental time investments in kids using data on childcare from time use surveys. Leisure is then the residual after subtracting hours worked and total childcare from waking time, which we set equal to 16. Finally, to obtain growth in human capital, we assume an even split of real wage growth between human capital and real wage per unit of human capital.

The most stringent requirement is the availability of micro data from consistent time use surveys. Such data were available for the following country-years: United States (2003-2019), Netherlands (1975-2006), Japan (1991-2016), South Korea (1999-2019), Mexico (2006-2019), and South Africa (2000-2010).

[10] In linking welfare through time within countries we use Tornqvist weights to value the factors. (E.g, growth on leisure from 2006 to 2007 is weighted by the average of relative time allocated to leisure in 2006 and 2007). In linking two countries in 2006, we use the average of their weights on an argument in that year to weight the country differences. (E.g, the percent leisure difference between the U.S. and the Netherlands in 2006 is weighted by the average of relative time allocated to leisure in 2006 in the U.S. and in the Netherlands.)

## 5.3 Results

Table 6 presents our micro-data calculations of CEW growth alongside our baseline macro calculations for the same six countries. We adjust the period of the macro calculation to match the years for which we have micro data. The table mostly shows modest net effects on total CEW growth from our added "per capita" terms (last three columns). The clear exception is Mexico, for which annual welfare growth is reduced from 6.5% to 3.3%. The culprits are falling leisure and little rise in quality of kids to offset their falling quantity.

The gaps between the macro and micro CEW growth rates largely reflect smaller population terms in the micro results. Repeating the point we emphasized earlier: taking into account parental altruism toward their kids leads to double counting kids' consumption, so that a smaller increase in consumption is equivalent to the value placed on additional people. But Table 6 shows that, quantitatively, this adjustment in the population term is modest, and population growth remains an important contributor to CEW growth.

Table 7 gives the *share* of CEW growth due to population growth in each of the six countries. We first note that this fraction is fairly similar between our macro and micro calculations, with the exceptions of South Korea and Japan, for which the adjustment is more substantial. The table also reports results entertaining higher and lower values of $\theta$ (the parameter governing diminishing returns in utility from having kids), or $v_k$ relative to $v_p$ for the U.S. in 2006 (kid's versus adult's value of a life year relative to their consumption). The baseline value of $\theta$ is 0.8, with larger and smaller values considered of 1.0 and 0.6. The baseline value of $v_k/v_p$ is 1, with larger and smaller ratios being 1.2 and 0.8. The share of growth due to population growth changes only modestly when we entertain these alternative parameter values.

Table 6: CEW Growth: Macro versus Micro Calcualtions

| | MACRO | | | MICRO | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | CEW growth | pop term | cons term | CEW growth | pop term | cons term | leisure term | quality term | quantity term |
| USA | 5.4 | 3.9 | 1.5 | 4.8 | 3.2 | 1.5 | 0.1 | 0.2 | −0.3 |
| NLD | 4.5 | 2.5 | 2.1 | 3.9 | 2.0 | 2.1 | 0 | 0.4 | −0.4 |
| JPN | 2.3 | 0.4 | 1.9 | 1.9 | 0.1 | 1.9 | 0 | 0.2 | −0.4 |
| KOR | 4.4 | 1.7 | 2.6 | 3.8 | 1.0 | 2.6 | 0.6 | 0.4 | −0.8 |
| MEX | 6.5 | 4.9 | 1.6 | 3.7 | 3.3 | 1.5 | −0.3 | 0.1 | −0.8 |
| ZAF | 6.8 | 4.3 | 2.6 | 5.6 | 2.8 | 2.4 | 1 | 0.3 | −1 |

Notes: 'MACRO' results are based on the framework presented in Section 2, while the 'MICRO' results are based on the augmented framework presented in Section 5. CEW denotes percent average annual consumption-equivalent welfare growth, decomposed in subsequent columns to show contribution of the different terms. The period is 2003-2019 for the United States, 1975-2006 for Netherlands, 1991-2016 for Japan, 1999-2019 for Korea, 2006-2019 for Mexico, and 2000-2010 for South Africa. Data sources are the Penn World Table 10.0 for population, consumption, and hours worked, time use surveys for fertility ("quality"), World Bank data on population for the number of kids per adult ("quantity").

Table 7: Share of population growth in CEW growth: Macro versus Micro

| | | MICRO | | | | |
|---|---|---|---|---|---|---|
| | | | Robustness | | | |
| | MACRO | Baseline | Larger $\theta$ | Smaller $\theta$ | Larger $v_k$ | Smaller $v_k$ |
| USA | 72% | 68% | 69% | 66% | 68% | 67% |
| NLD | 54% | 50% | 52% | 48% | 48% | 52% |
| JPN | 16% | 8% | 10% | 6% | −6% | 18% |
| KOR | 40% | 27% | 30% | 24% | 19% | 34% |
| MEX | 76% | 87% | 90% | 85% | 87% | 88% |
| ZAF | 63% | 51% | 53% | 48% | 49% | 52% |

Notes: CEW denotes consumption-equivalent social welfare growth. The share of growth due to population growth is the ratio of the population terms to overall CEW growth. For data sources and years see the notes to Table 6. The baseline value of $\theta$ is 0.8 and the larger and smaller values are 1.0 and 0.6. The baseline value of $v_k/v_p$ is 1, and the larger and smaller ratios are 1.2 and 0.8.

## 6. Conclusion

While the growth literature has almost invariably focused on per capita outcomes, we incorporate the value a country creates by adding more people. That is, we use a total utilitarian approach to value population growth in consumption-equivalent terms. Because of the diminishing marginal utility of consumption, each additional point of population growth is worth about five percentage points of per capita consumption growth in rich countries. Across a wider sample of 101 countries from 1960 to 2019, a percent of population growth is worth 2.7 percentage points of per capita consumption growth.

Countries with slow population growth — such as China, Japan, and Germany — plummet in our growth rankings. In contrast, middle-income countries exhibiting above-average population growth, such as Mexico, Brazil, and South Africa, move up. Lower income countries with rapid population growth, such as Ethiopia, do not move up as much because of the low standard of living used to weight their population growth.

We found our results to be robust to incorporating inequality, adjusting for migration, and incorporating parental utility from children and privately optimal fertility choices. Crediting migration entirely to source countries has modest net effects in most countries and does not alter our conclusions. Similarly, taking into account intergenerational utility has modest net effects because leisure exhibits little trend and the "quality" of kids is rising to offset the falling quantity of kids.

# A. Derivation of CE welfare growth

## A.1 Baseline: equation (1)

To begin, include $\lambda_t$ as an adjustment to consumption so that $W_t = N_t \cdot u(\lambda_t c_t)$ and totally differentiate:

$$\begin{aligned} dW_t &= dN_t\, u(\cdot) + N_t u'(\cdot)\left[c_t d\lambda_t + \lambda_t dc_t\right] \\ \Rightarrow \frac{dW_t}{W_t} &= \frac{dN_t}{N_t} + \frac{u'(\lambda_t c_t)\lambda_t c_t}{u(\lambda_t c_t)}\left[\frac{d\lambda_t}{\lambda_t} + \frac{dc_t}{c_t}\right] \end{aligned}$$

To get the consumption-equivalent measure, we solve for the growth rate of $\lambda_t$ that keeps us at the original level of welfare so that $dW_t = 0$ and we evaluate at the initial level of welfare with $\lambda = 1$:

$$\underbrace{g_{\lambda t} \equiv -\frac{d\lambda_t}{\lambda_t}}_{\text{CE welfare growth}} = \underbrace{\frac{u(c_t)}{u'(c_t)c_t}}_{\equiv v(c_t)} \cdot \frac{dN_t}{N_t} + \frac{dc_t}{c_t} \tag{12}$$

## A.2 With Heterogeneity: equation (5)

We include $\lambda_t$ as an adjustment to consumption of all individuals:

$$W(\lambda_t) = N_t \cdot \mathbb{E}_t u(\lambda_t \cdot c_{it})$$

Given log utility and the log-normal distribution of consumption:

$$W(\lambda_t) = N_t \cdot \left[\tilde{u} + \log \lambda_t + \log c_t - \frac{1}{2} \cdot \sigma_t^2\right]$$

Totally differentiating yields:

$$\frac{dW_t}{W_t} = \frac{dN_t}{N_t} + \frac{1}{\tilde{u} + \log \lambda_t + \log c_t - 1/2 \cdot \sigma_t^2}\left(\frac{d\lambda_t}{\lambda_t} + \frac{dc_t}{c_t} - \sigma_t \cdot \frac{d\sigma_t}{\sigma_t}\right).$$

To get the consumption-equivalent measure, we solve for the growth rate of $\lambda_t$ that keeps us at the original level of welfare so that $dW_t = 0$ and we evaluate at the initial

level of welfare with $\lambda = 1$:

$$g_\lambda \;=\; \left(\tilde{u} + \log c_t - \frac{1}{2}\cdot\sigma_t^2\right)\cdot\frac{dN_t}{N_t} \;+\; \frac{dc_t}{c_t} \;-\; \sigma_t\cdot\frac{d\sigma_t}{\sigma_t}.$$

## A.3 Beyond Consumption: equation (8)

Consider adjusted social welfare:

$$W(\lambda_t) = \; N_t^p\cdot u\left(\lambda_t c_t^p, l_t, \lambda_t c_t^k, h_t^k, b_t\right) + N_t^k\cdot\widetilde{u}\left(\lambda_t c_t^k\right).$$

We then set $dW/W \;=\; 0$ and solve for growth in consumption-equivalent welfare $g_{\lambda t} \equiv -d\lambda_t/\lambda_t$ around the initial level of welfare with $\lambda = 1$, which yields:

$$\begin{aligned}
g_{\lambda_t} = \kappa_t\Bigg[&\omega_t^p\left(\frac{dN_t^P}{N_t^P} + \frac{u_{c_t^p}c_t^p}{U_t}\frac{dc_t^p}{c_t^p} + \frac{u_{lt}l_t}{U_t}\frac{dl_t}{l_t} + \frac{u_{c^kt}c_t^k}{U_t}\frac{dc_t^k}{c_t^k} + \frac{u_{h^kt}h_t^k}{U_t}\frac{dh_t^k}{h_t^k} + \frac{u_{bt}b_t}{U_t}\frac{db_t}{b_t}\right)\\
&+\;\omega_t^k\left(\frac{dN_t^K}{N_t^K} + \frac{\tilde{u}'(c_t^k)c_t^k}{\tilde{u}(c_t^k)}\frac{dc_t^k}{c_t^k}\right)\Bigg],\\
\text{where}\quad \kappa_t \;&\equiv\; \left[\omega_t^p\cdot\left(\frac{u_{c_t^p}\cdot c_t^p}{U_t} \;+\; \frac{u_{c^kt}\cdot c_t^k}{U_t}\right) \;+\; \omega_t^k\cdot\frac{\tilde{u}'(c_t^k)\cdot c_t^k}{\tilde{u}(c_t^k)}\right],\\
\omega_t^p \;&\equiv\; \frac{N_t^p\cdot U_t}{N_t^P\cdot U_t \;+\; N_t^K\cdot\widetilde{u}(c_t^k)},\\
\omega_t^k \;&\equiv\; \frac{N_t^K\cdot\widetilde{u}(c_t^k)}{N_t^P\cdot U_t \;+\; N_t^K\cdot\widetilde{u}(c_t^k)}.
\end{aligned}$$

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