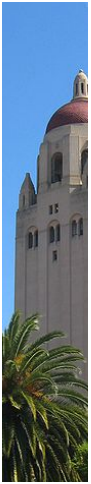


Population and Welfare:

The Greatest Good for the Greatest Number

Pete Klenow, Chad Jones, Mark Bils, and Mohamad Adhami

September 2023

Motivation

- Economic growth is typically measured in per capita terms

Motivation

- Economic growth is typically measured in per capita terms
    - Puts **zero** weight on having more people – extreme!

Motivation

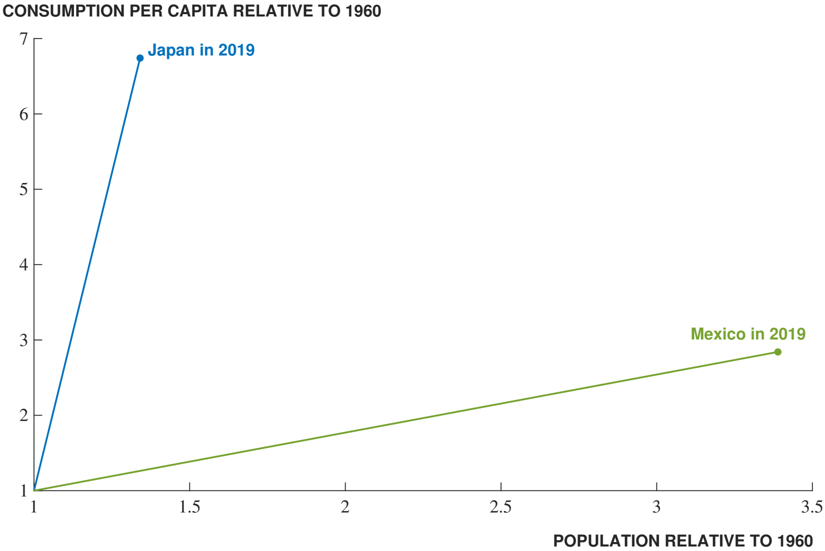
- Economic growth is typically measured in per capita terms
    - Puts **zero** weight on having more people – extreme!
- *Hypothetical:* Two countries with same time path for TFP.
    - One country keeps pop constant so that $\uparrow$ TFP $\implies$ $\uparrow$ cons per capita
    - The other keeps cons per capita constant so that $\uparrow$ TFP $\implies$ $\uparrow$ pop

Motivation

- Economic growth is typically measured in per capita terms
    - Puts **zero** weight on having more people – extreme!

- *Hypothetical:* Two countries with same time path for TFP.
    - One country keeps pop constant so that $\uparrow$ TFP $\implies$ $\uparrow$ cons per capita
    - The other keeps cons per capita constant so that $\uparrow$ TFP $\implies$ $\uparrow$ pop
    - Traditional focus on cons per capita $\implies$ first country more successful
    - Odd given the two have exactly the same production possibility frontiers

A real world example



This paper

- Develop a consumption equivalent metric of aggregate welfare growth:
  - Based on a total utilitarian criterion valuing people and cons per capita
  - Puts “humans” into a Human Development Index
- Reconsider pace of economic growth over time and across countries
- **Key Question:**

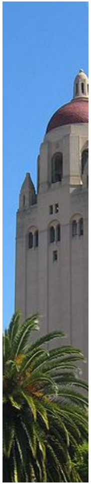
  How much has population growth contributed to aggregate welfare growth?

Why should we care?

- For some questions, pop size is part of the *social* cost-benefit analysis:
  - Impact of The Black Death, HIV/AIDS, or China’s one child-policy
  - What fraction of GDP to spend on mitigating climate change?
- **This paper** is about the social indifference curve
  - We use the MRS in aggregate welfare between people N and per capita c
- **What we’re not doing:** “drawing” the social production possibility frontier
  - Social MRT is complementary ingredient for such cost-benefit analysis
  - But requires quantifying externalities from ideas, human capital, pollution
  - And don’t need it to account for welfare growth along an expansion path

Outline

- **Part I.** Baseline calculation with only population and consumption
- **Part II.** Robustness
- **Part III.** Incorporating parental altruism and endogenous fertility



Part I. Baseline calculation with only population and consumption

Flow Aggregate Welfare

- Setup
  - N_t identical people in the country in year t
  - c_t consumption per person in year t
  - $u(c_t)$ flow of utility enjoyed by each person with $u'(c) > 0$ and $u''(c) < 0$
- Summing over people $\Rightarrow$ aggregate utility flow

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

  - $u(c_t) \geq 0$ so non-existence is valued at zero
  - Assumes “utility when not born” = “utility when dead”

Growth in consumption-equivalent aggregate welfare

Consumption equivalent welfare:

$$W\left(N_t\ ,\ \boldsymbol{\lambda_t}\cdot c_t\right)=W\left(N_{t+dt}\ ,\ c_{t+dt}\right)$$

Growth in consumption-equivalent aggregate welfare

Consumption equivalent welfare:

$$W\left(N_t\ ,\ \boldsymbol{\lambda_t}\cdot c_t\right) = W\left(N_{t+dt}\ ,\ c_{t+dt}\right)$$

$$\boxed{\underbrace{g_\lambda}_{\text{CE-Welfare growth}} = \underbrace{\frac{u(c_t)}{u'(c_t)c_t}}_{\equiv v(c_t)}\cdot\frac{dN_t}{N_t} + \frac{dc_t}{c_t}}$$

- 1 pp of population growth is worth $v(c)$ pp of consumption growth
- $v(c)$ = value of having one more person live for a year
    - expressed relative to one year of per capita consumption

Calibrating $v(c)$ in the U.S. in 2006

- Hall, Jones and Klenow (2020) show that the fraction of consumption an individual is willing to sacrifice in order to decrease the death rate by δ p.p. is

$$\delta \cdot v(c) \cdot LE$$

  - Links $v(c)$ to Value of Statistical Life (VSL):

$$v(c) \cdot LE \cdot c = \text{VSL}$$

- Using a VSL of \$7.4m in 2006 (EPA), with $c = \$38$k and LE of 40 at age 40:

$$v(c) = \frac{\text{VSL}/LE_{40}}{c} \approx \frac{\$7,400,000/40}{\$38,000} = \frac{\$185,000}{\$38,000} \approx 4.87$$

Measuring $v(c)$ in other years and countries

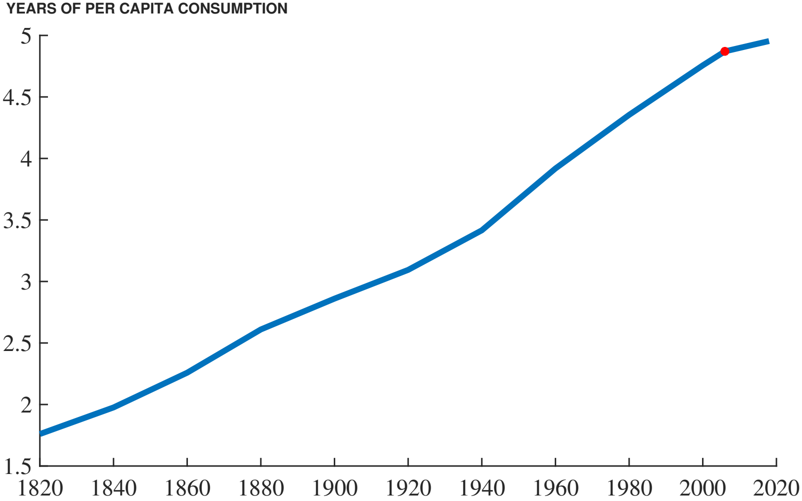
- Baseline: Assume $u(c) = \bar{u} + \log c$

$$v(c) \equiv \frac{u(c)}{u'(c) \cdot c} = u(c) = \bar{u} + \log c$$

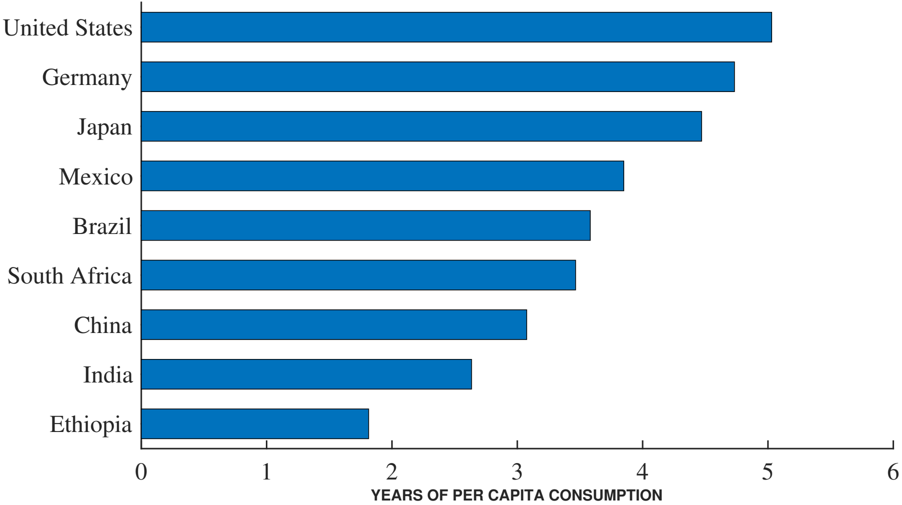
Higher consumption raises the value of a year of life

- Calibration:
  - Normalize units so that $c_{2006,US} = 1$
  - Then $v(c_{2006,US}) = 4.87$ implies $\bar{u} = 4.87$

$v(c)$ over time in the U.S.



$v(c)$ across countries in 2019



Recap

$$g_\lambda = v(c) \cdot g_N + g_c$$

λ is consumption-equivalent welfare

g_N is population growth

g_c is the growth rate of per capita consumption

- If $v(c) = 1$, then CE-Welfare growth is just aggregate consumption growth
- But find $v(c) > 1$, so larger weight on population growth
  - Intuition: consumption runs into diminishing returns

Implementation

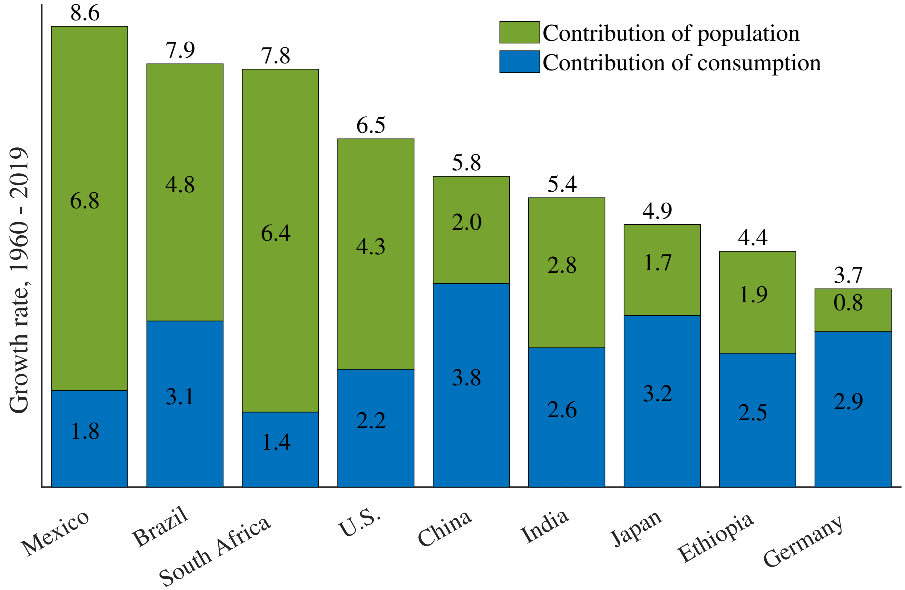
- Data source: Penn World Tables 10.0 (Feenstra, Inklaar and Timmer, 2015)
- Sample consists of 101 countries with yearly data between **1960-2019**
  - Sample includes all OECD countries + 63 non-OECD countries
- Data on population and consumption per capita for each country-year
  - Consumption calculated as sum of private and government consumption
- For each country, we implement our calculation using annual data then average the result over longer time periods

Overview of baseline results

	Unweighted	Pop Weighted
CE-Welfare Growth	6.2%	5.9%
Population term	4.1%	3.1%
Consumption term	2.1%	2.8%
Population growth	1.8%	1.6%
Value of life $v(c)$	2.7	2.3
Pop Share of CE-Welfare Growth	66%	53%

In 78 of the 101 countries, Pop Share of CE-Welfare Growth $\geq 50\%$

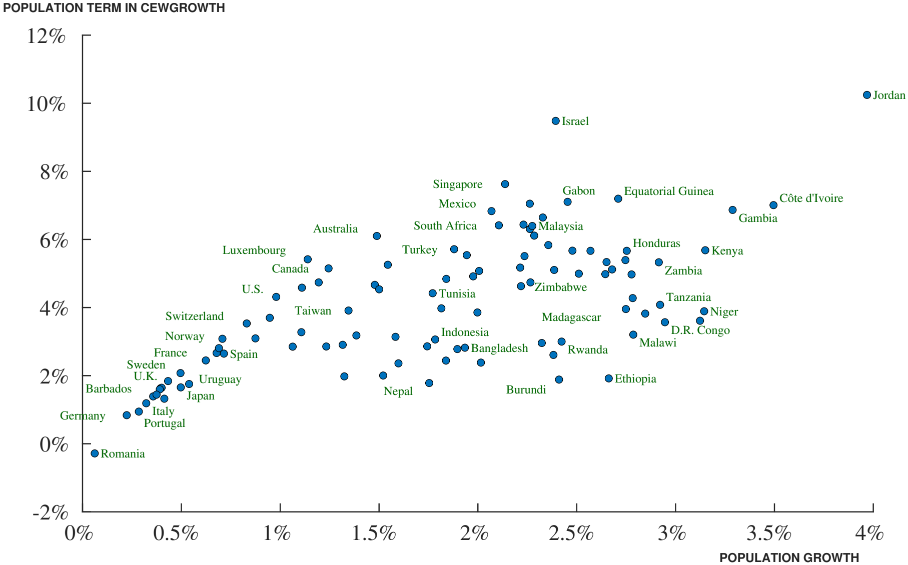
Average CE welfare growth for select countries



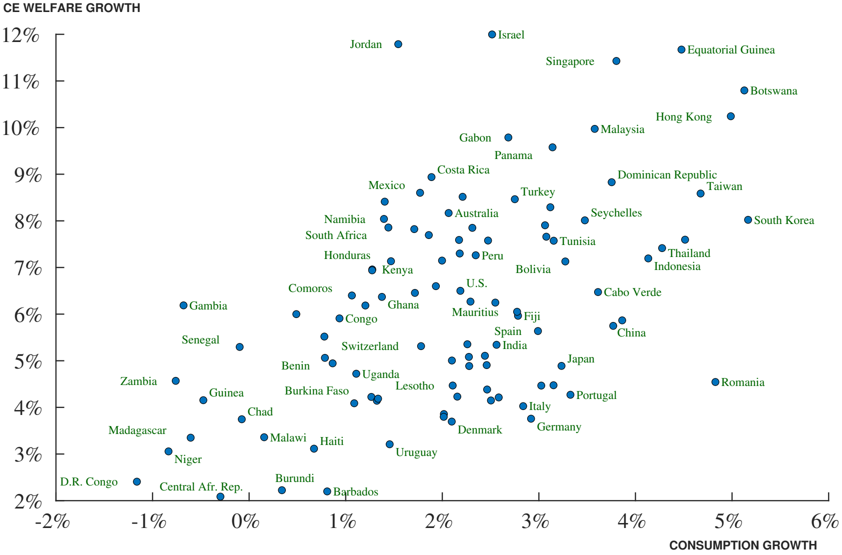
Decomposing welfare growth in select countries

	g_λ	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	7.9	1.4	2.1	3.1	6.4	82%
United States	6.5	2.2	1.0	4.4	4.3	66%
China	5.7	3.8	1.3	1.8	2.0	34%
India	5.3	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	3.8	2.9	0.2	4.0	0.8	22%

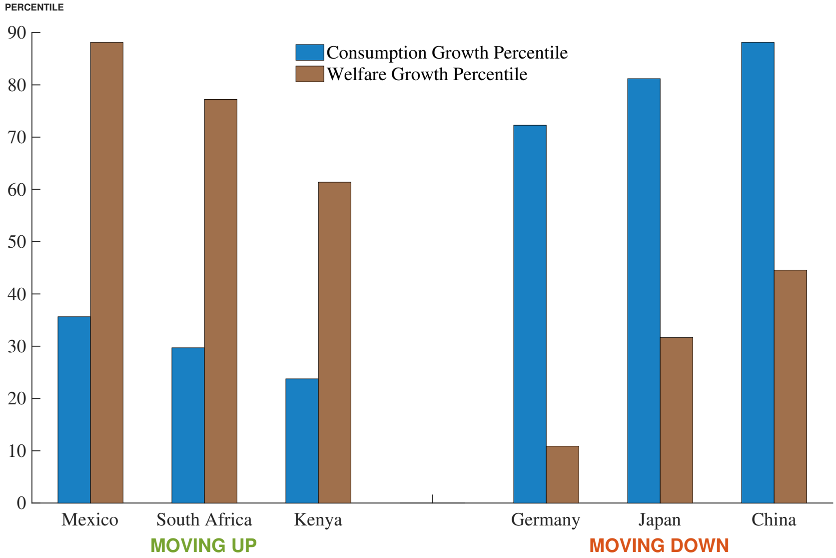
CE-Welfare Growth against Population Growth



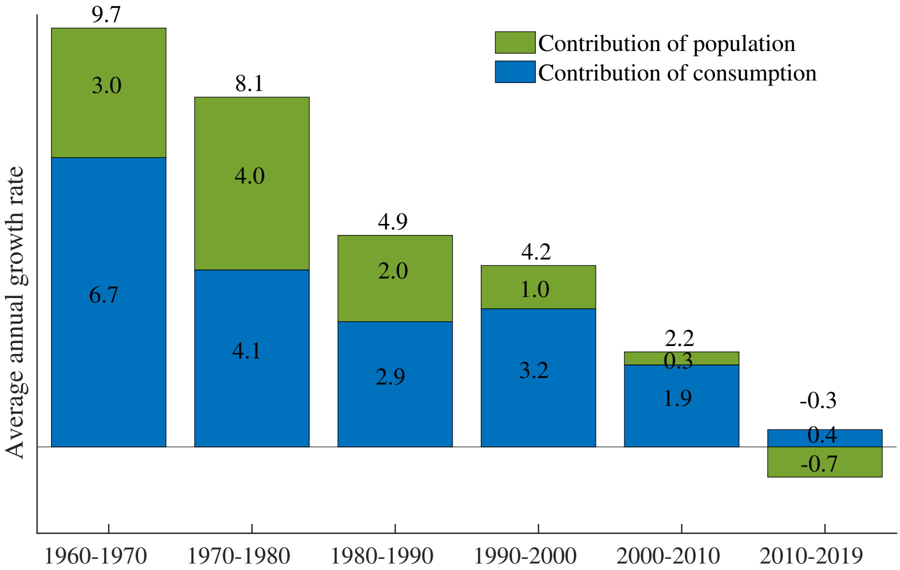
CE-Welfare Growth against Consumption Growth



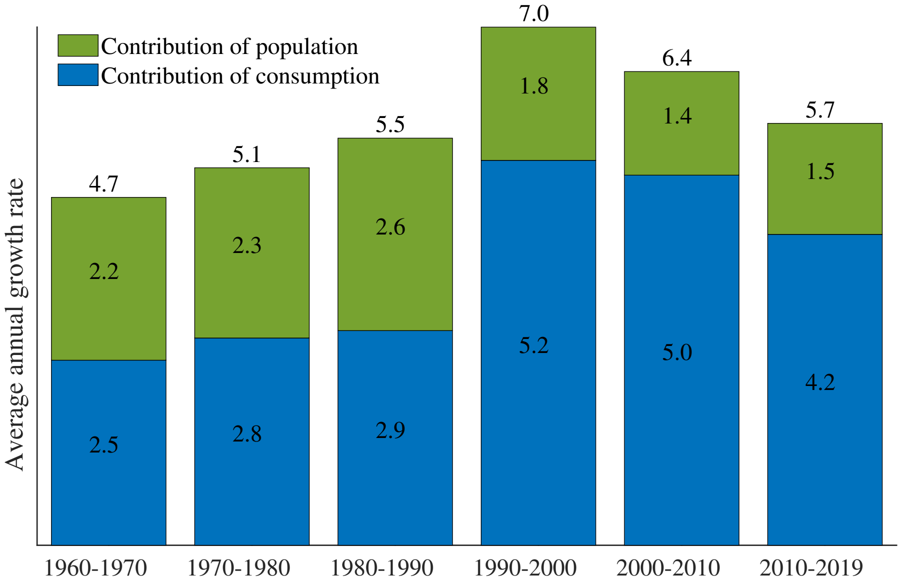
Some big differences in percentiles

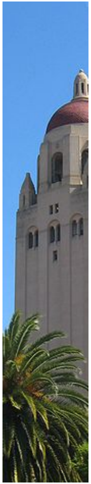


Average annual growth in Japan



Average annual growth in China





Part II. Robustness

Robustness

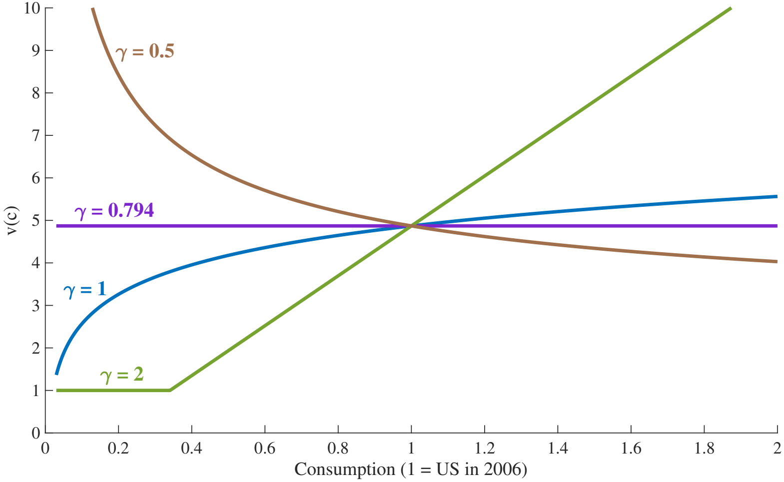
We explore the robustness of our baseline results to:

- Alternative calibrations of $\bar{u}$
- Alternative values for the CRRA γ
- No decline in mortality rates
- Adjusting for migration

Robustness to values for $\overline{u}$

- Baseline calibration of $\bar{u}$ targets $v(c_{US,2006}) = 4.87$
    - $v(c)$ we get for developing countries consistent with the range used by the World Health Organization to determine the cost effectiveness of spending to avoid lost life years due to mortality.
- Consider robustness to cutting by half, or increasing by 50%
    - Imply U.S. VSL_{2006} of $3.7 mil and $11.1 mil, vs. $7.7 mil for baseline
    - U.S. Dept. of Transp. (2013) states $4 to $10 mil as plausible for VSL_{2001}
    - Range we consider implies values for VSL_{2001} of $2.8 to $8.6 mil

$v(c)$ for different values of γ



Weight on population growth is very high, either in past or future or both!

Robustness: CEW growth

	Pop weighted Mean	US	Japan	Mexico	Ethiopia
Per capita consumption	2.8%	2.2%	3.2%	1.8%	2.5%
Baseline	5.9%	6.5%	4.9%	8.6%	4.4%
Baseline ($v \geq 1$)	6.0%	6.5%	4.9%	8.6%	5.2%
$\bar{u} = 2.4$ ($v \geq 1$)	4.5%	4.1%	3.8%	4.0%	5.1%
$\bar{u} = 7.3$ ($v \geq 1$)	9.8%	8.9%	6.1%	13.6%	10.9%
$\gamma = 2$ ($v \geq 1$)	4.6%	5.1%	3.7%	3.8%	5.1%
Constant $v = 4.87$ ($\gamma = 0.79$)	10.6%	7.0%	5.7%	11.9%	15.5%
Constant $v = 2.7$ ($\gamma = 0.63$)	7.1%	4.8%	4.6%	7.4%	9.7%
Constant $v = 1$ ($\gamma = 0$)	4.4%	3.2%	3.7%	3.8%	5.1%

Note: Baseline corresponds to $\gamma = 1$, $\bar{u} = 4.87$, and variable $v(c)$

Contribution of longevity

- Population grows through births and increased longevity
- Thought experiment to separate the two: no decline in death rate
  - Given data on pop, age distribution and death rate by age
  - Simulate a counterfactual where death rate by age is fixed at 1960 level
  - Gap between actual and counterfactual pop growth rate reflects contribution of longevity to pop growth
- Implementation for 24 (mostly rich) countries
  - Data source: The Human Mortality Database

Contribution of longevity

5 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%
24 countries – pop. weighted	0.72%	0.53%

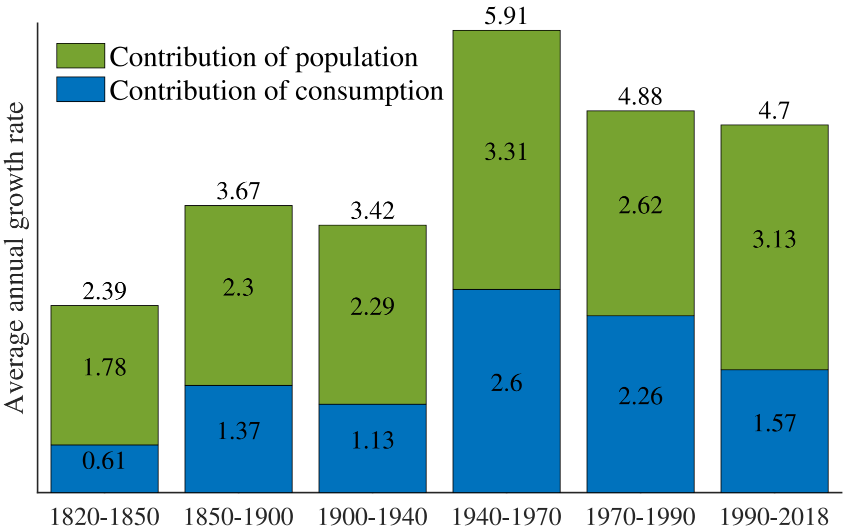
- We typically value increasing life expectancy (Jones and Klenow, 2016)
- Our approach values increases in life-years, regardless of the source

Dealing with migration

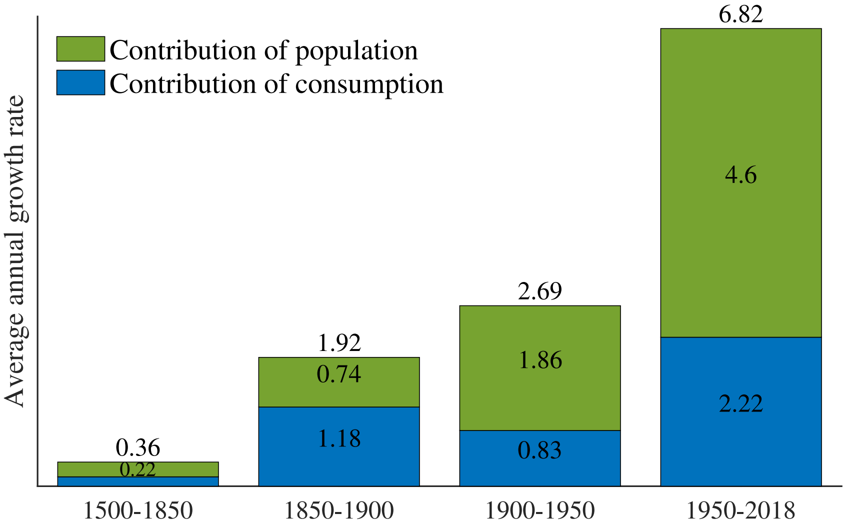
- Immigration is another source of population growth
    - Should countries receive “credit” for population growth from immigration?
    - In our baseline approach, they do

- First consider aggregating to deal with this issue:
    - “The West” from 1820 to encompass the Age of Mass Migration
    - “The World” from 1500 onward
    - Using data from Maddison (2020) for both

West CE-Welfare growth over the long run, 1820-2018



World CE-Welfare growth over the long run, 1500-2018



Adjusting *country* welfare for migration

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

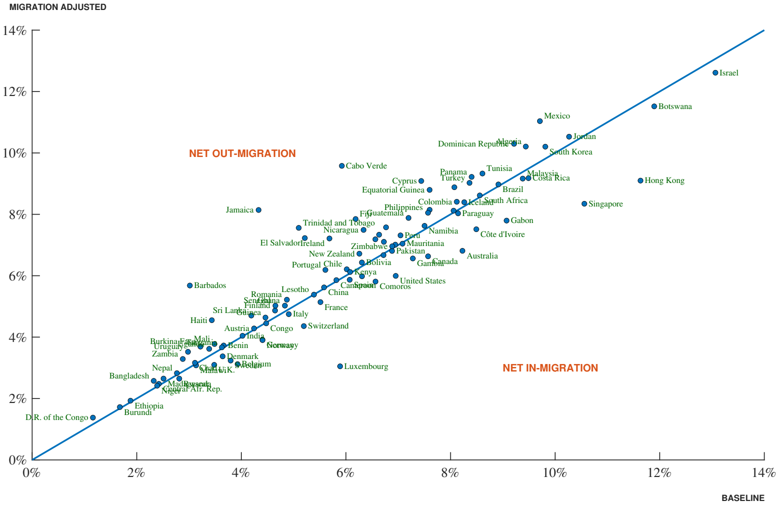
- $N_{i \to j,t} =$ population born in country i, living in country j in year t
- $N_{j \to i,t} =$ population born in country j, living in country i in year t
- Baseline credits all immigrants to **destination** country
- Migration adjustment credits them to **source** country instead

Growth in country welfare adjusted for migration

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

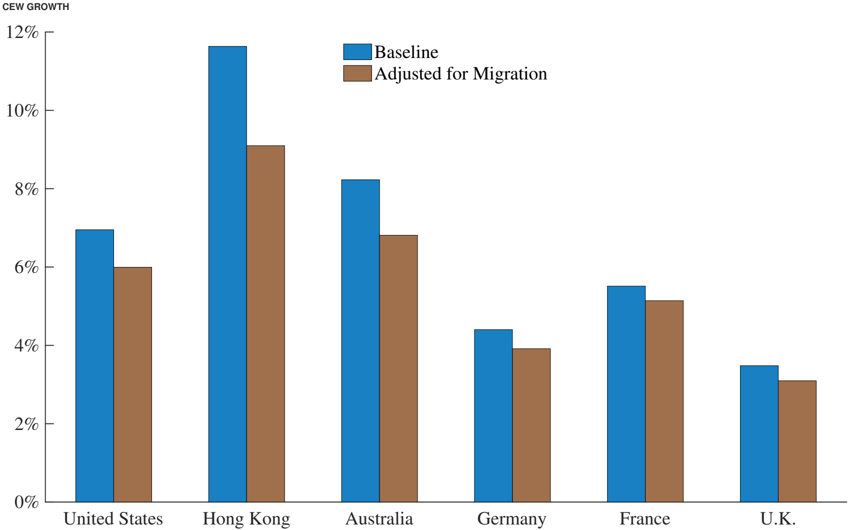
- Implementation for 81 countries from 1960 to 2000
- Source: World Bank's Global Bilateral Migration Database

Baseline vs. Migration-Adjusted CEW growth

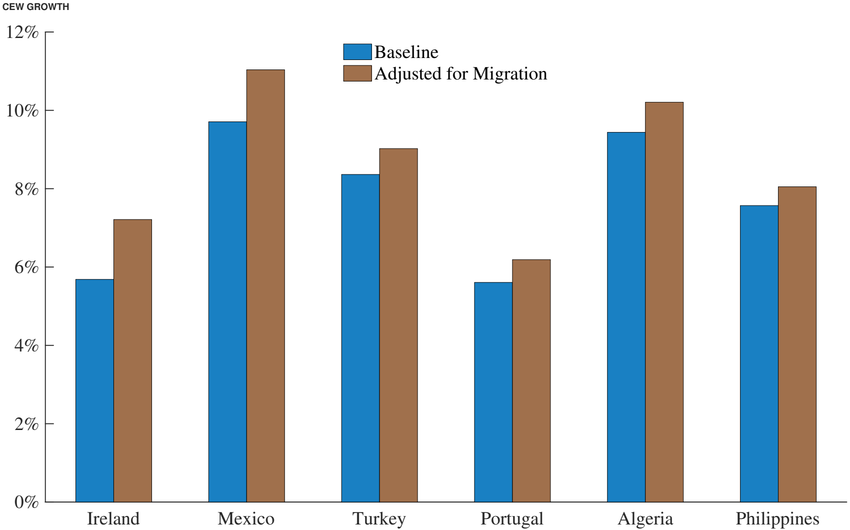


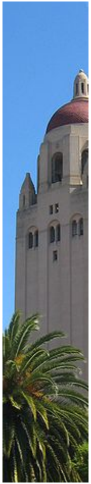
The correlation between the two is 0.92 and the average absolute adjustment is 0.6pp

Countries for which in-migration biases our baseline upward



Countries for which out-migration biases our baseline downward





Part III. Parental altruism and endogenous fertility

Parental altruism and fertility

- Fertility is the outcome of optimizing behavior by parents
    - Parents have kids because they love them – missing in our baseline
    - Account for effect of reduced fertility on parental welfare (Cordoba, 2015)
- But falling fertility may be compensated by higher per capita utility:
    - Quantity / quality trade-off $\implies$ fewer but “better” kids
    - Or maybe substitute from childcare towards leisure
- Accordingly, extend framework to incorporate:
    - Broader measure of flow utility, including quantity/quality of kids
    - *Privately* optimal fertility, consumption, and time use by parents

Flow aggregate welfare

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

- N^p = number of adults
- N^k = number of children
- b = number of children per adult

$$\Longrightarrow \;\; N = N^p + N^k = (1+b)\cdot N^p$$

- c^p = adult consumption
- l = adult leisure
- c^k = child consumption
- h^k = child human capital

Consumption equivalent welfare:

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

Parental utility maximization problem

$$\max_{c^p,\, l,\, c^k,\, h^k,\, b} u(c_t^p,\, l_t,\, c_t^k,\, h_t^k,\, b_t)$$

$$\text{subject to: } c_t^p + b_t \cdot c_t^k \leq w_t \cdot h_t \cdot l_{ct}$$

$$h_t^k = f_t(h_t \cdot e_t) \quad \text{and} \quad l_{ct} + l_t + b_t \cdot e_t \leq 1$$

- w = wage per unit of human capital
- h = parental human capital, equals inherited h^k
- l_c = parental hours worked
- e = parental time investment per child

Functional Forms

- Make two assumptions on preferences:
  - *Assumption 1:* $u(c_t^p, c_t^k\ ,\ \vec{x}_t) \ = \ \log(c_t^p) \ + \ \alpha b_t^\theta \cdot \log(c_t^k) \ + \ g(l_t, b_t, h_t^k)$
  - *Assumption 2:* $\widetilde{u}(c^k) \ = \ \bar{u}_k \ + \ \log(c_t^k)$

- Define

$$v\left(c_t^p, c_t^k, \vec{x}_t\right) = \frac{u\left(c_t^p, c_t^k, \vec{x}_t\right)}{u_{c^p}\left(c_t^p, c_t^k, \vec{x}_t\right) \cdot c_t^p} \quad \text{and} \quad \tilde{v}(c_t^k) = \frac{\widetilde{u}(c_t^k)}{\widetilde{u}'(c_t^k) \cdot c_t^k}$$

Consumption-equivalent welfare growth

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

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

Special case – just for intuition

- Let $\theta = 1 \Rightarrow \frac{dc^k}{c^k} = \frac{dc^p}{c^p}$ and evaluate at $\tilde{v}(c_t^k) = v\left(c_t^p, c_t^k, \vec{x}_t\right) = v(c_t)$

$$
\begin{aligned}
g_{\lambda_t} \quad = \quad & \frac{dc_t}{c_t} + \frac{N_t^p + N_t^k}{N_t^p + 2 \cdot N_t^k} \cdot v(c_t) \cdot \frac{dN_t}{N_t} \\
& + \frac{N_t^p}{N_t^p + 2 \cdot N_t^k} \cdot \frac{u_{lt} l_t}{u_{ct} c_t} \cdot \frac{dl_t}{l_t} \\
& + \frac{N_t^p}{N_t^p + 2 \cdot N_t^k} \cdot \frac{u_{bt} b_t}{u_{ct} c_t} \cdot \frac{db_t}{b_t} \\
& + \frac{N_t^p}{N_t^p + 2 \cdot N_t^k} \cdot \frac{u_{h^k t} h_t^k}{u_{ct} c_t} \cdot \frac{dh_t^k}{h_t^k}
\end{aligned}
$$

Double counting kids' consumption downweights all non-consumption terms

Measurement

- Parent's utility maximization $\implies \frac{c_t^k}{c_t^p} = \alpha b_t^{\theta-1}$
  - Conditional on calibrating α and θ, do not need data on c^k vs c^p
- Parents' FOCs maps weights in growth accounting to observables
  - l_t: $\frac{u_{lt}\cdot l_t}{u_{c^p t}\cdot c_t^p} = \frac{w_t\cdot h_t\cdot l_t}{c_t^p}$
  - b_t: $\frac{u_{bt}\cdot b_t}{u_{c^p t}\cdot c_t^p} = \frac{N_t^k}{N_t^p}\cdot\frac{(c_t^k+w_t\cdot h_t\cdot e_t)}{c_t^p}$
  - h_t^k: $\frac{u_{h^k t}\cdot h_t^k}{u_{c^p t}\cdot c_t^p} = \frac{N_t^k}{N_t^p}\cdot\frac{1}{\eta_t}\cdot\frac{w_t\cdot h_t\cdot e_t}{c_t^p}$, where: $\eta_t = \frac{f'(h_t e_t)\cdot h_t e_t}{f(h_t e_t)}$
- e_t measured as childcare in time use surveys
- To obtain growth in h, assume an even split of real wage growth between human capital and real wage per unit of human capital

Calibration

- Parental altruism parameters
    - $\frac{c_t^k}{c_t} = \alpha b^{\theta-1} \implies$ calibrate using spending on kids vs. parents (Lino, 2011)
    - Spending in households with two parents and two children $\implies \alpha = 2/3$
    - Those with one child spend more *per child* suggesting $\theta = 0.8$
- Elasticity of h^k wrt $h \cdot e$ set to $\eta = 0.24$ (Lee, Roys & Seshadri et al, 2015)
- For parents, target $v^p = 4.87$ in the US in 2006
    - Allow $v(c_t^p, c_t^k, \vec{x}_t)$ to evolve across countries & time using chain weighting
- For kids, $\tilde{v}(c_t^k) = \bar{u}_k + log(c_t^k)$
    - To calibrate $\bar{u}_k$, assume value of year of life relative to consumption is the same for child and adult in U.S. in 2006

Data to implement generalized growth accounting

- To implement calculation need series for:
    - # Children = 0-19 years old
    - # Adults = 20+ years old
    - $b_t =$ Children / Adults
    - l_{ct} = paid work
    - $b_t e_t$ = total child care
    - l_t = 16 hrs $- l_{ct} - b_t \cdot e_t$
- Childcare from time use is main data constraint, restrict to 6 countries:
    - US (2003–2019)
    - Netherlands (1975–2006)
    - Japan (1991–2016)
    - South Korea (1999–2019)
    - Mexico (2006–2019)
    - South Africa (2000-2010)
- Additional data sources: PWT for per capita consumption and average market hours worked for ages 20-64, World Bank for population by age group

CEW Growth: Macro vs Micro

	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	1.6	-0.3	0.1	-0.8
ZAF	6.8	4.3	2.6	5.6	2.8	2.6	1	0.3	-1

Share of population in CEW growth: Macro vs Micro

	MACRO	MICRO				
		Baseline	Robustness			
			Larger θ	Smaller θ	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%

Conclusions

- Each additional point of population growth is worth:
  - 5pp of consumption growth in rich countries today
  - an average of 2.7pp for the world as a whole
- Population growth:
  - Contributes more than per-capita cons. growth in 78 of 101 countries
  - Weighting by population, contributes comparably to cons. growth
  - Shuffles countries perceived as growth miracles
- Results are robust to adjusting for migration and parental altruism