7. Secular Stagnation

Adv. Macro: Heterogenous Agent Models

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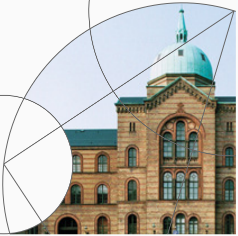
2024



Introduction

Secular Stagnation

- **Today:** Can we explain *secular stagnation* through the lens of heterogeneous agent models?

- **Central economic questions:**
  1. How do aging populations affect interest rates and global imbalances?
  2. What will happen going forward?
  3. Should we be concerned about an asset market meltdown?

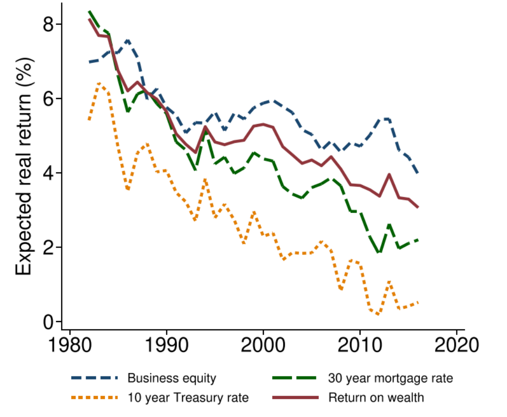
- **Plan for today:** Discuss two possible explanations for observed secular stagnation:
  1. Population aging
  2. Increase in income inequality

Secular Stagnation

- **Secular stagnation**: A state in which private demand is structurally low
  - Low level of growth in the economy
  - Low interest rates
  - Low level of inflation
- Large litterature suggests that advanced economies have been in this state over the past $\approx$ 20 years

Declining interest rates

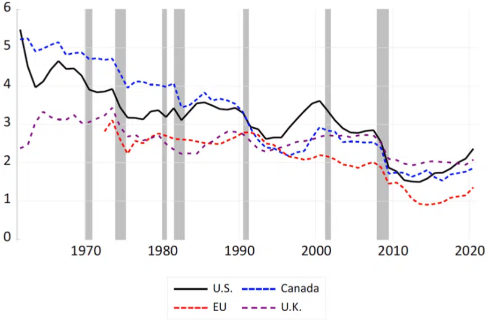
Various interest rates from Mian, Sufi, Straub (2021)



Declining growth

Trend Real Output Growth, 1961 to 2020

Percent



Source: www.cbo.gov/system/files/2020-12/56891-real%20-interest-rates.pdf

Data sources: Holston et al. (2017) and Federal Reserve Bank of New York, "Measuring the Natural Rate of Interest" (accessed December 10, 2020), www.newyorkfed.org/research/policy/rstar.

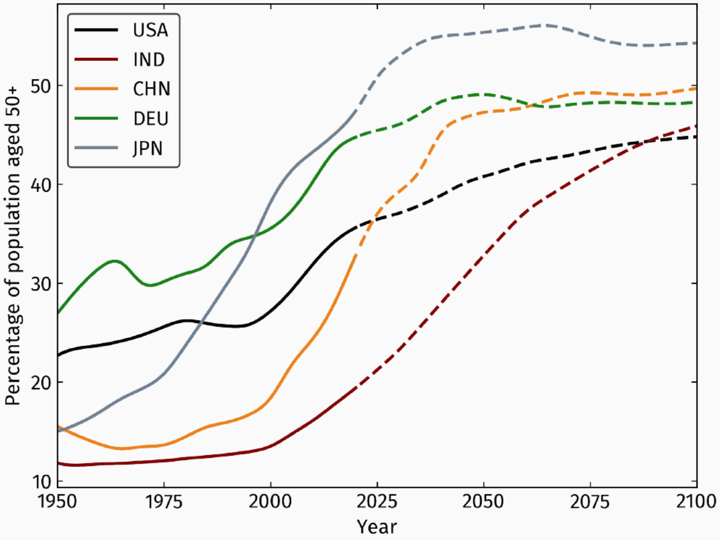
Explanations

Large litterature on potential explanations

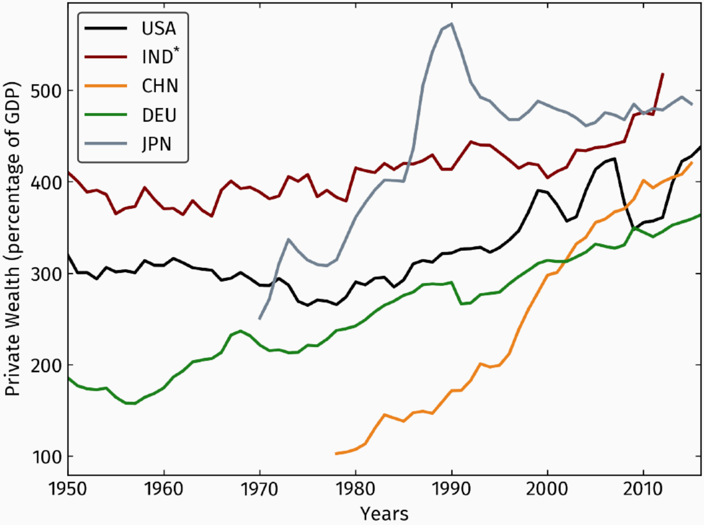
- Increases in market power of firms
  - Liu, Mian & Sufi (2022), Aghion, Bergeaud, Boppart, Klenow & Li (2023)
- Declining relative price of investment (/reduced innovation)
  - Eichengreen (2015), Eggertsson, Mehrotra & Robbins (2019)
- **Aging population (Demographics)**
  - Auclert, Malmberg, Martenet & Rognlie (2021), Gagnon, Johannsen & López-Salido (2021)
- **Increasing income inequality**
  - Straub (2019), Mian, Sufi & Straub (2021)

Demographics

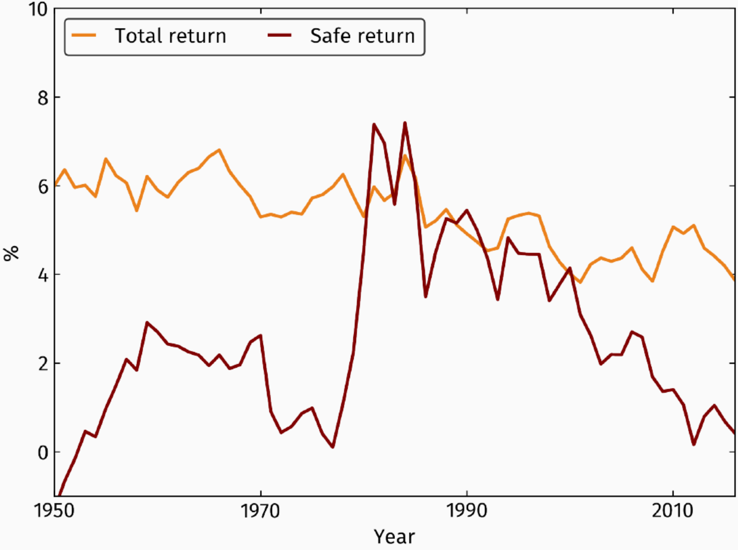
The world population is aging



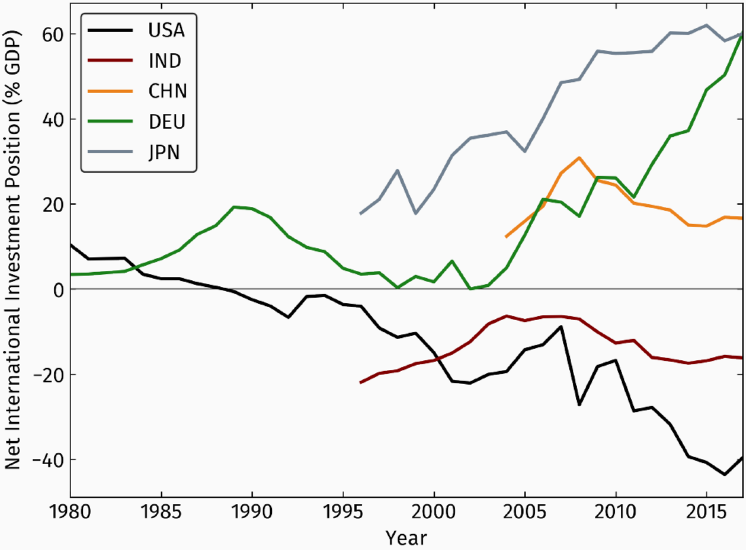
...wealth-to-GDP ratios are increasing...



...rates of return on wealth are falling...



...and "global imbalances" are rising



How have demographics shaped these trends?

- Broad agreement that demographics has contributed to historical trends in W/Y, real returns (r), and NFA imbalances

- Older population saves more, unevenly across countries

- Much less agreement about how much: Δr for 1970-2015 is

  $> -100\text{bp}$ in Gagnon-Johannsen-Lopez-Salido 2021

  $< -30\text{bp}$ in Eggertsson-Mehrotra-Robbins 2019

And how will demographics continue to shape these trends?

- Critical question: what will happen going forward?

- Influential view that these trends will revert:
  - "While a large population cohort that is saving for retirement puts upward pressure on the total savings rate, a large elderly cohort may push down aggregate savings by running down accumulated wealth." [Lane, ECB 2020]
  - "asset market meltdown" hypothesis [Poterba 2001]
    - If large elderly cohort wishes to sell assets to younger, smaller cohort asset prices drop, rates increase
  - "great demographic reversal" hypothesis [Goodhart-Pradhan 2020]
    - Demographic shift may raise rates going forward
    - (**Less**): Young who consume and produce (i.e. supply labor)
    - (**More**): Old who only consume
    - $\Rightarrow$ Increase in demand with lower supply: inflationary

And how will demographics continue to shape these trends?

- "Demographics, Wealth, and Global Imbalances in the Twenty-First Century" by Auclert, Malmberg, Martenet and Rognlie (2021) attempts to answer these questions
- These authors develop a multi-country model with overlapping generations of households and equilibrium world interest rates
  - Demographic change alters demand for assets in each country
  - This affects world interest rate & financial flows between countries
- Big challenge: how to take this model to the data to discipline the importance of demographics?

Taking the model to the data

- The authors develop a sufficient statistic approach to answer this question
- First, they show analytically that the effect of demographic change on W/Y, r, and NFA depends only on:
  1. Age profiles of wealth, labor income, and consumption
  2. Demographic projections
  3. The elasticity of intertemporal substitution
  4. The elasticity of substitution between capital and labor
- Second, they use this framework to measure the importance of demographic change
- Admittedly, this approach requires a lot of simplifying assumptions. The authors solve and simulate the full model and show that it gives similar results

Main results

- The authors reject the "great demographic reversal" hypothesis
  - Do not find that aging will decrease savings and increase interest rates
  - Instead, it appears the global savings glut has just begun
- In addition, the authors refute the "asset market meltdown" hypothesis
  - Will dissaving of the old reverse the effects of demographics?
  - Yes, slightly. But it does not cause r to increase
  - As a result, no asset market meltdown

Model

Model: Main Elements

- OLG model, demographic change + multiple countries facing $\{r_t\}$
- Demographics
  - Exogenous, time-varying sequence of births N_{0t} [will drive demo. change in stylized model]
  - Exogenous, constant sequence of mortality rates ϕ_j
  - No migration
- Production
  - Aggregate production function with capital and effective labor, with elasticity of substitution η
  - Constant growth rate of labor-augmenting technology γ
  - Perfect competition, free capital adjustment
- Government
  - Flow budget constraint

$$G_t + w_t \sum_{j=0}^{T} N_{jt} \mathbb{E} tr_j + (1 + r_t) B_{t-1} = \tau w_t \sum_{j=0}^{T} N_{jt} \mathbb{E} l_j + B_t$$

  - Balance budget by changing G_t, not τ_t or tr_{jt}, to keep Bt/Yt

Environment: heterogeneous agents

- Problem for heterogeneous agents of cohort k (age $j \equiv t - k$)}

$$\max \mathbb{E}_k \left[\sum_j \beta_j \Phi_j \frac{c_{jt}^{1-\frac{1}{\sigma}}}{1-\frac{1}{\sigma}} \right],$$

$$\text{s.t } c_{jt} + a_{j,t} \leq w_t \left((1-\tau)\ell(z_j) + tr(z_j) \right) + (1 + r_t)\, a_{j-1,t-1}$$

$$a_{j,t} \geq -\underline{a}$$

- $\sigma \equiv$ elasticity of intertemporal substitution
- β_j : age-specific discount rate
- Φ_j : survival probability by age $\left(\Phi_j = \prod_j \phi_j\right)$
- $\ell(z_j)$: risky labor supply driven by age specific stochastic process z_j
- $\tau, tr\left(z^j\right)$: taxes and (state-contingent) government transfers
- a_{jt} : savings

Equilibrium

Given demographics and policy, in an integrated world equilibrium:

- Individuals optimize
- Firms optimize
- Global asset markets clear

$$\sum_c W_t^c = \sum_c (K_t^c + B_t^c) \quad \forall t$$

where W_t^c is aggregate household wealth in country c:

$$W_t^c = \sum_{j=0}^{J} N_{jt}^c a_{jt}^c$$

Next: consider small country aging alone, with world at steady state
$\rightarrow r$ constant (will adjust later)

Compositional effects as sufficient statistics

Proposition 1

The wealth-to-GDP ratio of a small country aging alone with constant rate r and growth γ follows

$$\frac{W_t}{Y_t} \propto \frac{\sum_j \pi_{jt} a_{jo}}{\sum_j \pi_{jt} h_{jo}}$$

where $a_{j0} \equiv \mathbb{E} a_{j,0}$ and $h_{j0} = \mathbb{E} w_0 \ell_{j,0}$ are average initial asset holdings and pretax labor income by age, and $\pi_{jt} = N_{jt}/N_t$ is the share of the population of age j.

In a partial equilibrium world (where r does not adjust to changing demographics) then all changes in W/Y reflect the changing age composition π_{jt} of the population, given fixed profiles of asset holdings by age (a_{j0}) and income by age (h_{j0}).

Compositional effects as sufficient statistics

Based on Proposition 1, we can compute the change in log wealth to GDP ratio as follows:

$$\log\left(\frac{W_t}{Y_t}\right) - \log\left(\frac{W_o}{Y_o}\right) = \log\left(\frac{\sum_j \pi_{jt} a_{jo}}{\sum_j \pi_{jt} h_{j0}}\right) - \log\left(\frac{\sum_j \pi_{j0} a_{jo}}{\sum_j \pi_{jo} h_{j0}}\right) \equiv \Delta_t^{comp}$$

- The above is measurable from demographic projections and hh. surveys
- Why? Demographics do not affect (normalized) individual decisions
  - **Note**: Comes from SOE **assumption** (constant r)
- Later: we'll think about how Δ_t^{comp} affects general equilibrium outcomes

Measuring compositional effects

Measuring Δ^{comp}

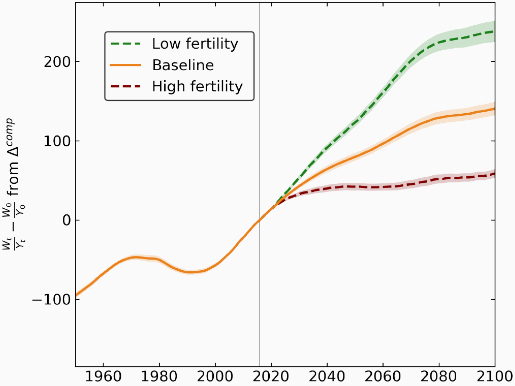
- Calculate Δ_t^{comp} for 25 countries:

$$\Delta_t^{comp} \equiv \log\left(\frac{\sum \pi_{jt} a_{j0}}{\sum \pi_{jt} h_{j0}}\right) - \log\left(\frac{\sum \pi_{j0} a_{jo}}{\sum \pi_{j0} h_{j0}}\right)$$

- Data:
  - π_{jt} : projections of age distributions over individuals 2019 UN World Population Prospects
  - a_{jo}, h_{jo} age-wealth and labor income profiles in base year
    - For US: SCF, LIS/CPS, and Sabelhaus-Henriques Volz (2019)
    - a_{j0} includes funded part of DB pensions
    - Household $\rightarrow$ individual (j) by splitting wealth among adults
- Report implied level change $\frac{W_t}{Y_t} - \frac{W_0}{Y_0} = \frac{W_0}{Y_0}\left(\exp\left\{\Delta_t^{comp}\right\} - 1\right)$

Δ^{comp} in the United States: 1950-2100

- Composition effect implies that increase in average population age (low fertility scenario) increases W/Y



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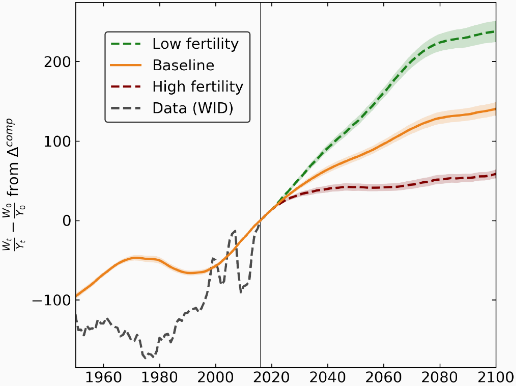

Where do these large effects come from?

- Does increase in W/Y come from increase in **agg. wealth W**, or decrease in **agg. income Y**?

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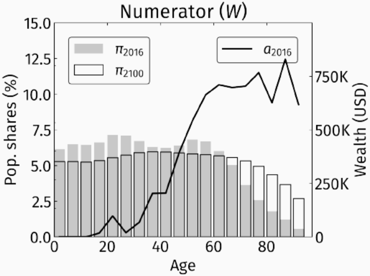

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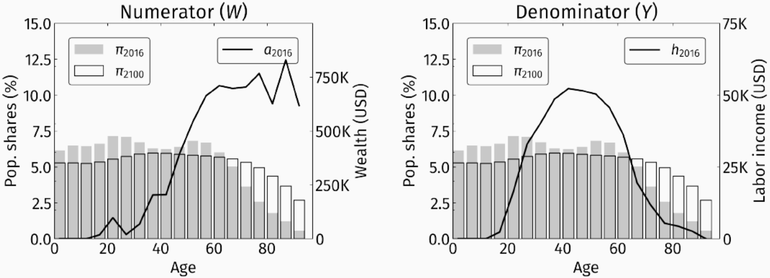

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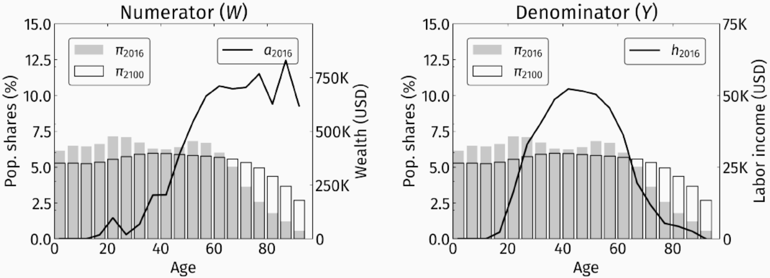

- In paper: separate contribution of numerator (wealth) and denominator (income)
  - Going forward: W contributes $\sim 2/3$, Y contributes $\sim 1/3$
  - Historically demographic dividend pushed Y up, reversed in 2010

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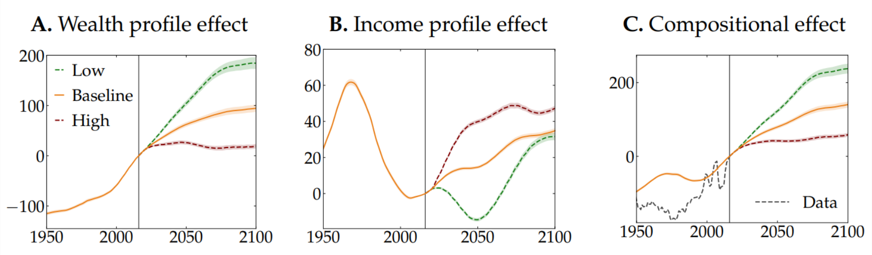
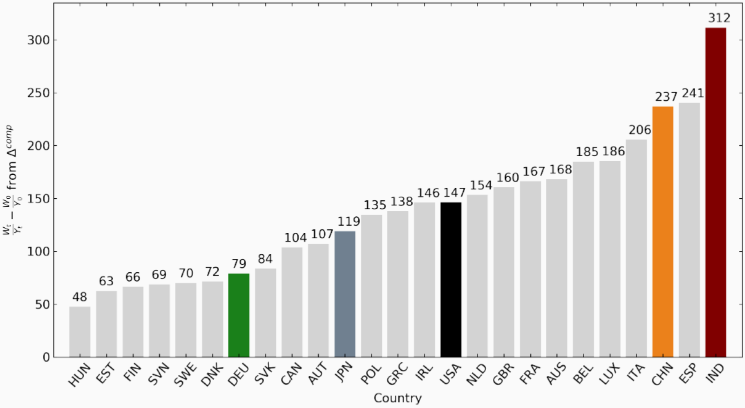


- Historically (btw. 1970 and 2010) "demographic dividend" pushed up Y, decreased W/Y as a larger share of households were at peak working age where labor income is highest
- But this effect has been less pronounced recently, as elderly households earn less

Across countries, Δ^{comp} large and heterogeneous by 2100

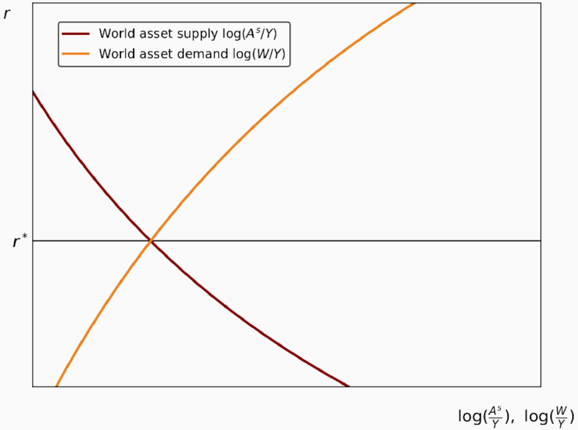


- **Note**: Uses US saving/income age profiles

General equilibrium

- So far: Change age distribution keeping
  - World interest rate r fixed
  - Household consumption/saving behavior fixed
- Now: **General equilibrium**
- Changing the age distribution will affect *supply* of wealth (demand for assets)
- Equilibrium r will depend on supply of assets (gov. bonds + firm capital) as well

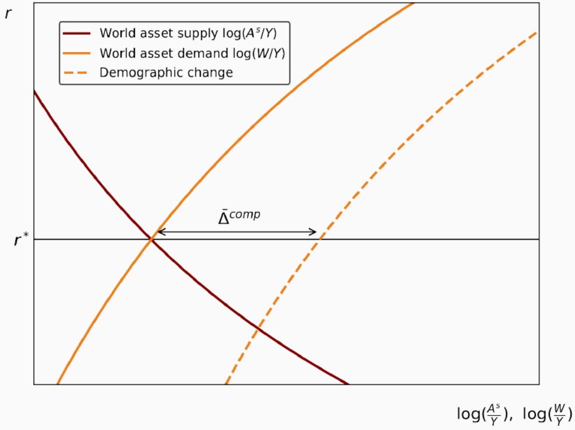
General equilibrium implications



Semielasticity of asset demand $\bar{\epsilon}_d = \frac{\partial \ln(W/Y)}{\partial r}$: depends on elasticity of intertemporal substitution σ and observables (HHs)

Semielasticity of asset supply $\bar{\epsilon}_s = -\frac{\partial \ln((K+B)/Y)}{\partial r}$: depends on elasticity of

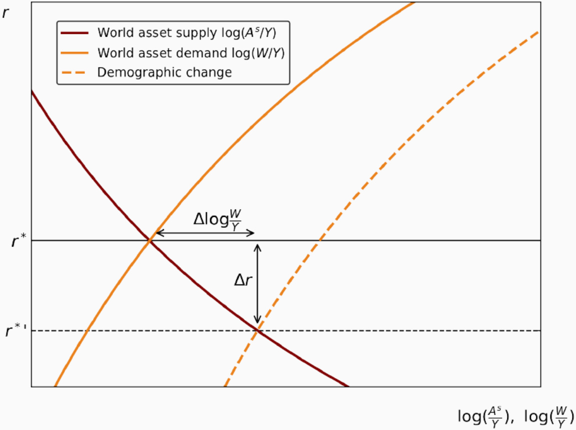
General equilibrium implications



Asset demand shift of $\overline{\Delta}^{\text{comp}}$: wealth-weighted average of $\Delta^{\text{comp, c}}$

Large and positive in the data.

General equilibrium implications



General equilibrium implications

Proposition 2

If the age profiles of assets and consumption are constant, net foreign assets are zero, and governments maintain constaint debt-to-GDP ratios, then the long run change in the rate of return is:

$$\Delta r \approx -\frac{\bar{\Delta}^{\text{comp}}}{\bar{\epsilon}_S + \bar{\epsilon}_d}$$

where $\bar{\epsilon}_S$ is the average semielasticity of asset supply to r,and $\bar{\epsilon}_d$ is the average semielasticity of asset holdings to r, and $\bar{\Delta}^{\text{comp}}$ is the average compositional change.

- If asset demand/capital supply is very elastic: Small decline in r
  - HHs respond a lot to initial decline in r by saving less (crowding out direct effect $\bar{\Delta}^{\text{comp}}$), which stabilizes r in eq.
  - Firms respond by investing a lot in capital thereby driving up r in eq.

What determines the asset demand semielasticity?

$$\epsilon^d = \underbrace{\sigma \frac{C}{(1+g)W} \frac{\operatorname{Var} Age_c}{1+r}}_{\equiv \epsilon^d_{\text{substitution}}} + \underbrace{\frac{\mathbb{E}Age_c - \mathbb{E}Age_a}{1+r}}_{\equiv \epsilon^d_{\text{income}}}$$

- Age_a, Age_c: R.V. age weighted by assets/consumption
- The substitution effect:
  - Proportional to $\operatorname{Var} Age_c$ since there is more scope for intertemporal substitution if consumption is more spread out over the life cycle
- The income effect:
  - Reflects the fact that a higher r increases total income, if $\mathbb{E}Age_a < \mathbb{E}Age_c$ (i.e. the extra interest income is saved before it is consumed)
  - Note: Income effect can be negative since they allow for borrowing
- The above can be measured assuming fixed Age_a and Age_c
  - The authors find $\epsilon^d_{\text{substitution}} = 39.5$, $\epsilon^d_{\text{income}} = -2$, thus $\epsilon^d > 0$

What determines the asset supply semielasticity?

$$\bar{\epsilon}^s = \frac{\eta}{r_0 + \delta} \frac{\bar{K}_0}{\bar{W}_0}$$

- η is the elasticity of substitution between capital and labor
- $r_0 + \delta = 9.7\%$ is the user cost of capital
- $\frac{\bar{K}_0}{\bar{W}_0} = 0.78$ is the initial global capital-wealth ratio
- Based on the above calibration, $\bar{\epsilon}^s > 0$ for any plausible η.
- Note: Holds for fixed gov. bond supply

Change in world interest rate

Since $\bar{\epsilon}_S + \bar{\epsilon}_d > 0$, then the change in the world interest rate must be negative:

$$\Delta r \approx -\frac{\bar{\Delta}^{\text{comp}}}{\bar{\epsilon}_S + \bar{\epsilon}_d} < 0$$

With different assumptions on the elasticity of intertemporal substitution (σ) and the elasticity of substitution between capital and labor (η), this gives:

	σ		
η	0.25	0.50	1.00
0.60	-3.24	-1.59	-0.79
1.00	-2.09	-1.25	-0.70
1.25	-1.71	-1.10	-0.65

Change in capital to income ratio

Proposition 2 gives a similar formula for the change in capital to income:

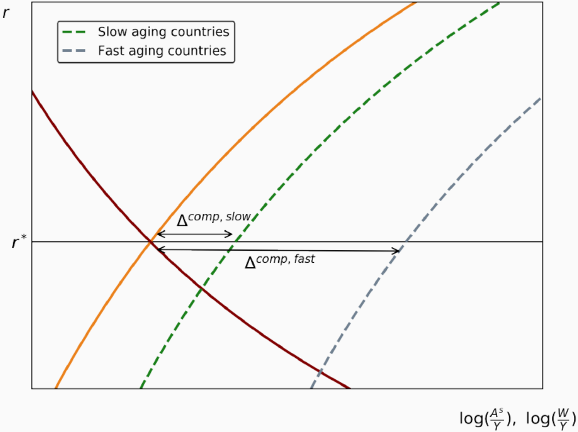
$$\overline{\Delta \log\left(\frac{W}{Y}\right)} \approx \frac{\bar{\epsilon}_{\mathrm{S}}}{\bar{\epsilon}_{\mathrm{S}} + \bar{\epsilon}_{d}} \bar{\Delta}^{\text{comp}} > 0$$

Again with different assumptions on the IES (σ) and the elasticity of substitution between capital and labor (η)

	σ		
η	0.25	0.50	1.00
0.60	15.6	7.7	3.8
1.00	16.7	10.0	5.6
1.25	17.1	11.1	6.5

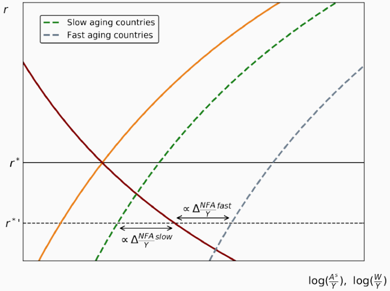
The authors argue that simulations from the general model deliver similar outcomes

Change in net foreign assets



Country specific Δ^{comp} large and heterogeneous in the data

Change in net foreign assets



- Countries that age faster will accumulate more wealth, which it supplies to the rest of the world (NFA>0)
  - Particularly to countries that age slowly (less wealth accumulation) where domestic firms need to go abroad for investments

$$\Delta\left(\frac{NFA}{Y}\right) \approx \frac{W_0}{Y_0}\left(\Delta^{\text{comp,c}} - \bar{\Delta}^{\text{comp}}\right)$$

Change in net foreign assets

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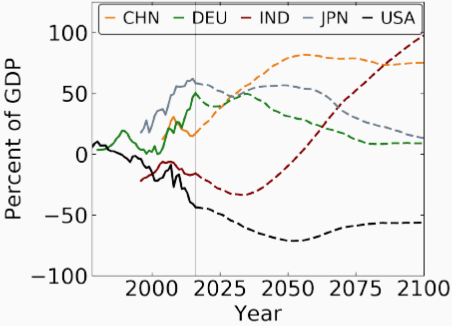

→ Data suggest large global imbalances going forward

Limitation to baseline model

- What are some limitations of their baseline analysis?
  - Demographics have no effect on individual savings
  - Demographics have no effect on the tax-and-transfer system
  - No bequest motives
  - No changes in mortality (only birth rates)
  - Demographics have no effect on TFP growth
- To study some of these changes, the authors extend their baseline model $\rightarrow$ then simulate the transition path

Results from richer model

- Compositional effect by country from analytical model product of:
  - Combination of demographic changes (exogenous in model) and labor supply/wealth profiles (endogenous)
- Could match perfectly in richer model if model could replicate observed wealth and labor profiles over the lifecycle
- Main finding: Δ^{comp} in the richer model is roughly similar to the results from the data

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	$\Delta^{comp,c}$	
Country	Model	Data
AUS	30	29
CAN	21	20
CHN	47	45
DEU	21	20
ESP	42	37
FRA	31	30
GBR	27	26
IND	65	56
ITA	34	30
JPN	24	22
NLD	34	33
USA	32	29

Results from richer model

- GE Effects from the model are also roughly similar

	Δr	$\overline{\Delta \log \frac{W}{Y}}$	$\bar{\Delta}^{comp}$	$\bar{\Delta}^{soe}$	$\bar{\epsilon}^{d}$	$\bar{\epsilon}^{s}$
Sufficient statistic analysis	-1.23	9.9	31.8		17.8	8.0
Preferred model specification	-1.23	10.3	34.1	30.3	17.1	8.0
Alternative model specifications						
+ Constant bequests	-1.18	10.0	34.1	27.0	14.9	8.0
+ Constant mortality	-1.23	10.9	34.1	27.1	13.8	8.0
+ Constant taxes and transfers	-1.33	11.9	34.1	30.1	14.5	8.0
+ Constant retirement age	-1.49	13.4	34.1	34.1	14.6	8.0
+ No income risk	-1.47	13.2	33.9	33.9	13.8	8.0
+ Annuities	-1.33	11.5	34.2	34.2	17.2	8.0
Alternative fiscal rules						
Only lower expenditures	-1.29	11.0	34.1	32.6	17.9	8.0
Only higher taxes	-0.88	6.7	34.1	19.4	14.6	8.0
Only lower benefits	-1.50	12.9	34.1	39.1	18.4	8.0

Notes: Δr, $\overline{\Delta \log \frac{W}{Y}}$, $\bar{\Delta}^{comp}$, and $\bar{\Delta}^{soe}$ denote the changes in the model simulation between 2016 and 2100, with Δr reported in percentage points and the other three reported in percent ($100 \cdot \log$).

Conclusion

- How does population aging affect wealth-output ratios, real interest rates, and capital flows?
  - what matters is the compositional effect Δ^{comp}
  - large and heterogeneous in the data
- The approach developed by the authors:
  - Refutes the asset market meltdown hypothesis: r falls
  - Suggests wealth-to-income ratio will keep rising
  - Larger global imbalances (dispersion of NFAs)

Income Inequality

Secular stagnation and income inequality

- Auclert et al (2021) explains decline in r and rise in $\frac{W}{Y}$ with demographic shifts
- Parallel literature explains decline through *rising* income/wealth **inequality**
  - See i.e. Mian, Sufi, Straub (2021): *What explains the decline in r*? Rising income inequality versus demographic shifts*
- **Example**: If saving rates increase with income (richer save more) then:
  - Redistribution from poor to rich households *increase* the aggregate supply of savings $\Rightarrow$ lower rates in GE
  - Suggests link between increasing income inequality and secular stagnation

Permanent redistribution in the canonical HA model

- Consider standard HA model with permanent income state p :

$$V\left(a_{t-1}, z_t, p\right) = \max_{c_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}\left[V\left(a_t, z_{t+1}, p\right)\right]$$

$$\text{subject to}$$

$$c_t + a_t = R a_{t-1} + z_t p$$

$$a_t \geq 0$$

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

- Note: preferences are *homothetic* (homogeneous of degree 1)
  - »Scale independent«
- Increase in permanent income by 1% increases c_t, a_t by 1%.
  - Permanent redistribution has *no effect* on aggregates because the dissavings by one group is exactly offset by increase in savings from other groups

Homothetic household problem I

- Normalize constraints by p and Bellman by $p^{1-\sigma}$

$$\frac{V\left(a_{t-1}, z_t, p\right)}{p^{1-\sigma}} = \max_{c_t} \frac{\frac{c_t^{1-\sigma}}{1-\sigma}}{p^{1-\sigma}} + \beta \frac{\mathbb{E}\left[V\left(a_t, z_{t+1}, p\right)\right]}{p^{1-\sigma}}$$

subject to

$$\frac{c_t}{p} + \frac{a_t}{p} = R\frac{a_{t-1}}{p} + z_t\frac{p}{p}$$

$$\frac{a_t}{p} \geq \frac{0}{p}$$

Homothetic household problem II

- Define $\tilde{c}_t = \frac{c_t}{p}$, $\tilde{a}_t = \frac{a_t}{p}$, $\tilde{V}_t = \frac{V_t}{p^{1-\sigma}}$ to get:

$$\tilde{V}\left(a_{t-1}, z_t\right) = \max_{c_t} \frac{\tilde{c}_t^{1-\sigma}}{1-\sigma} + \beta \mathbb{E}\left[\tilde{V}\left(a_t, z_{t+1}\right)\right]$$

$$\text{subject to}$$

$$\tilde{c}_t + \tilde{a}_t = R\tilde{a}_{t-1} + z_t$$

$$\tilde{a}_t \geq 0$$

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

- Then HH problem is independent of p up to scale!
  - Can always solve above HH problem, and get solution with different p by simply scaling policy functions $\tilde{c}_t, \tilde{a}_t$ by p
  - Solution is »scale independent«

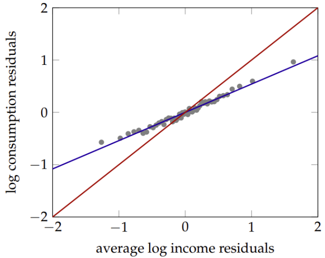
Straub (2019)

- Straub (2019) tests for homothetic preferences
- Let ϕ be the elasticity of consumption to permanent income, $\phi = \frac{\partial \ln c_t}{\partial \ln p_t}$
- Homothetic preferences (scale independence) imply $\phi = 1$ since $\tilde{c}_t = \frac{c_t}{p}$
- If $\phi < 1$ consumption rises *less* than proportionally with income
  - I.e. savings rise *more* $\Rightarrow$ Richer HHs save more
  - Opposite for $\phi > 1$
- Two questions
  - What does this elasticity look like emprically?
  - If $\phi \neq 1$ how can we accomodate this in a HA model?

Empirical estimate

- Use US panel survey data (PSID)
- Regress $\log c_{it}$ on controls (year, age, HH size, location) and 9 year average of income
- Binned scatter:

Figure 3: Consumption and average income.



- More detalied estimates in paper, suggest $\phi \approx 0.7$

Non-homothetic HA model

- Extend standard HA model with *taste for wealth* (»status«)

$$V(a_{t-1}, z_t, p) = \max_{c_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \phi_a \frac{a_t^{1-\sigma_a}}{1-\sigma_a} + \beta \mathbb{E}\left[V(a_t, z_{t+1}, p)\right]$$

subject to

$$c_t + a_t = a_{t-1}(1+r) + z_t p$$

$$a_t \geq 0$$

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

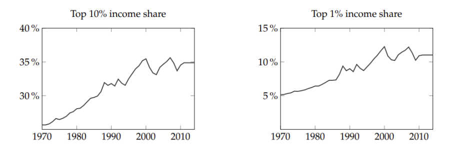
- Note: Still homothetic as long as $\sigma = \sigma_a$, but non-homothetic if $\sigma \neq \sigma_a$:

$$\tilde{V}(a_{t-1}, z_t, p) = \frac{\tilde{c}_t^{1-\sigma}}{1-\sigma} + \frac{1}{p^{1-\sigma}} \phi_a \frac{a_t^{1-\sigma_a}}{1-\sigma_a} + \beta \mathbb{E}\left[\tilde{V}(a_t, z_{t+1}, p)\right]$$

- If $\sigma \neq \sigma_a$ then scaling p up/down changes relative weight btw c, a

Applications

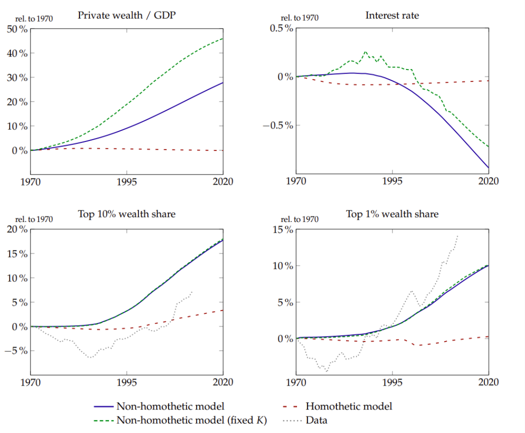
- Calibrate lifecycle HA model to with non-homothetic preferences to estimate $\phi = 0.7$
  - Note: In paper there is a second source of non-homotheticity where σ varies across age
- Segment HHs into 3 permanent income groups corresponding to poorest 90%, next 9% and richest 1%
- Feed in evlolution of income inequality from Piketty and Saez (2003), keeping aggregate income unchanged in PE (so permanent redistribution between rich and poor HHs)



- Solve for GE (Supply side as in HANC)

GE implications of rising income inequality

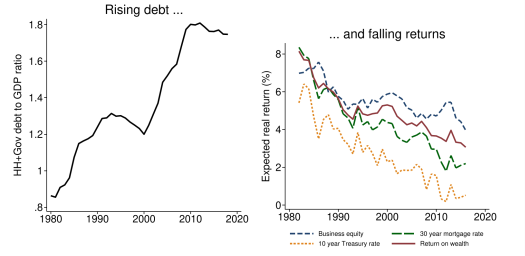
- Compare effects in homothetic and non-homothetic models:



- Note: »Fixed K« is Lucas-tree economy, where wealth grows due to rising asset prices

Indebted Demand (2021)

- Mian, Sufi, Straub (2021) »Indebted Demand« build on this insight of non-homothetic preferences
- Highlights role of increasing household debt and connect to returns:



- Argue that income inequality and less financial regulation leads to more borrowing and lower returns in GE
- **Note**: Would normally expect the opposite
  - If I want to borrow more, I will have to compensate savers by paying **higher** interest rate, not **lower**

Model

- Model:
  - **Continuous** time
  - Endowment economy with $Y = 1$
- Savers s are unconstrained and maximize utility:

$$\int_0^\infty e^{-\rho t} \left\{ \log \left\{ c_t^s \right\} + \nu \left(a_t^s \right) \right\} dt$$

- Borrowers b are constrained. They hold debt $d_t > 0$ up to a share ℓ of collateral $p_t = \int_t^\infty e^{-rt} \omega^b Y dt = \frac{\omega^b Y}{r}$

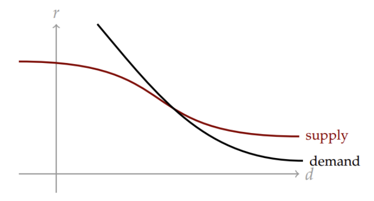
$$d_t = \frac{\ell \omega^b Y}{r}$$

- Equilibrium: Debt owed by borrowers equal savings by savers:

$$d_t = a_t^s$$

Non-homothetic model

- Calibration:
  - Interpret savers as top 1% of income distribution
  - Calibrate $\nu(a_t^s)$ such that savers have long run MPC of 0.01
- **Non-homotheticity**: Large differences in SR across the two types
- Core insight in paper: If savings is luxury good for rich $\nu''(a_t^s) > 0$ (needed for rich to save more) then saving schedule $a_t^s(r)$ is *downward sloping*



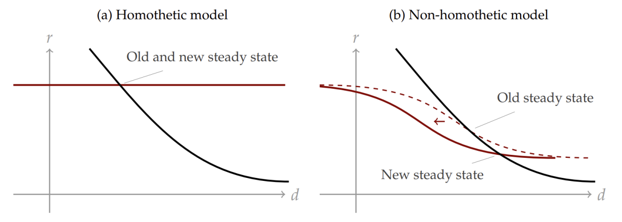
- Why? Assume rich agent consumes fixed amount $\overline{c}^s$ and saves everything else: Then $\overline{c}^s = r_t a_t^s \Leftrightarrow a_t^s = \frac{\overline{c}^s}{r_t}$
  - Higher r will in the long run crowd out a_t^s in the long run (needed for ss, rules out explosive path)

Results

- Increase in income inequality: Increase in debt and lower interest rates
  - Similar to Straub (2019)
- Increase in financial deregulation (relax borrowing constraint): More borrowing and lower interest rates
  - Note: standard GE argument would imply **higher** rates
  - Lower rates arise due to downward sloping saving schedule for savers

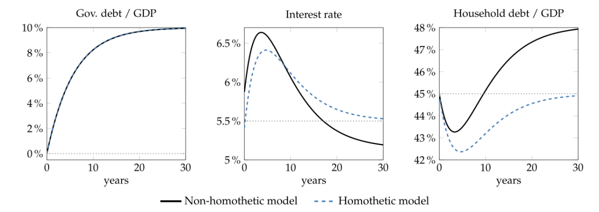
Results

- Graphically: Increase in income inequality moves supply curve (red) to the left
- Inequality $\uparrow \Rightarrow$ saving by rich $\Rightarrow$ lower r $\Rightarrow$ Incentive debt $d \uparrow$



Fiscal Policy

- Temporary government spending shock (deficit financed)
- Short run: Higher r required for HHs to hold increase in gov. debt
- **Long run** Increase in B pushes r down. Rich save more, pushing r further down and incentivizing holding of debt



Summary

- Basic premise of Mian, Sufi, Straub (2021): Savers and borrowers have different (permanent) marginal propensities to consume/save
  - Show that in their specification this implies a downward sloping saving schedule for rich households
  - Implies that increases in debt and savings can co-exist with lower interest rates
- Highlight implications for fiscal policy
  - And monetary policy - see paper

Exercise

- Consider the following PE HA model:

$$V\left(a_{t-1}, z_t, p\right) = \max_{c_t} \frac{c_t^{1-\sigma}}{1-\sigma} + \phi_a \frac{a_t^{1-\sigma_a}}{1-\sigma_a} + \beta \mathbb{E}\left[V\left(a_t, z_{t+1}, p\right)\right]$$

subject to

$$c_t + a_t = a_{t-1}\left(1+r\right) + z_t p$$

$$a_t \geq 0$$

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t$$

- **Q1**: Derive the Euler equation of the model
- **Q2:** Update the EGM algorithm in *household_problem.py* with the new Euler
- **Q3:** Solve the model with 1) $\phi_a = 0$, 2) $\phi_a = 0.1, \sigma = \sigma_a = 1$, 3) $\phi_a = 0.1, \sigma = 1, \sigma_a = 0.7$
  - Compare the normalized policy function c/p
- **Q4:** Conduct an experiment where you permanently redistribute resources across households (change p). What are the aggregate effects across the models?

Summary

- **Previously:** Long run wealth inequality
- **Today:** Explaining secular stagnation through HA models
  - Implications of aging population
  - Implications of permanent redistribution
- From now on: **Business cycles**
- Next lecture**: New Keynesian model + HANK**