Retirement Financing: An Optimal Reform Approach

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Motivation

- U.S. government has a major role in financing retirement

  social security benefits $\approx$ 40 percent of all elderly income

  main source of income for almost half of them

- A significant part of federal budget

  social security benefits $\approx$ 20 percent of federal expenditures

  FICA taxes $\approx$ 30 percent of federal tax receipts

- Demographic changes pose serious fiscal challenge

  $\rightarrow$ reform needed

What Kind of Reform

- Proposed reforms are of two varieties:

  Cut taxes, cut benefits → move towards a "privatized" system

  Raise taxes → expand the current system as need in response to demog.

- Typically, these proposals

  are limited to the payroll tax reform,

  focus on gains to future generations – with rare exceptions,

  have winners and losers within generations

- Can we find Pareto-improving policy reforms?

  so that no current/future generation and no income level is hurt

This Paper Makes Three Points

- We develop a methodology to study Pareto optimal policy reform
  - Test Pareto optimality of - any - status quo policy
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- Progressive asset subsidies are important:
  - To correct for inefficiencies due to imperfect annuity markets
  - To reduce the distortionary cost of redistribution

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  - Characterize Pareto optimal policies
- Progressive asset subsidies are important:
  - To correct for inefficiencies due to imperfect annuity markets
  - To reduce the distortionary cost of redistribution
- Reforming earnings tax schedule is not so important

Review of Findings

efficiency of earning taxes

- Pareto-improvement is possible *iff*

  status quo tax/transfer is inefficient within each generation

  ⇒ possible to collect same revenue at lower distortionary cost

- A tax system is more likely to be inefficient if

  lower tax rates does not result in lower tax revenues

  i.e., there is a *Laffer* effect

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- This is more likely to be the case when
  - elasticity of labor supply is high
  - earning tax is regressive (e.g., earnings cap on FICA tax)

Review of Findings

efficiency of asset taxes/subsidies

- If there is heterogeneity in mortality, asset taxes can improve efficiency

  high ability has higher valuation for old age consumption

  taxing old consumption of low income people, discourages shirking

  $\Rightarrow$ effort can be induced at lower distortionary cost

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- When both features are present,

  the interaction determines the nature of the optimal policy

Review of Findings

quantitative exercise

- To implement these ideas we use quantitative model with
  - workers: heterogeneous in their ability, mortality and discount factor
  - markets: non-existent annuity market
  - policies: status quo US policies (US tax code, SS payroll tax/transfer, etc)
- Calibrate to the US data, and calculate status quo welfare
- Find policies that
  - minimize cost to government
  - deliver the status quo welfare (or higher) to each individual

Review of Findings
quantitative exercise

- Earning tax reforms are not a major source of efficiency gains

  $\rightarrow$ optimal earning taxes are very similar to status quo

- Efficient asset taxes are negative and progressive
  - average marginal subsidy on asset post retirement = 5%
  - subsidy rates are higher for poorer individuals

- Optimal policies lower PDV of net transfers to each cohort by 5%

Related Literature

- **Retirement reform:** Conesa-Carriga (2008), Nishiyama-Smetters (2007), Kitao (2005), McGrattan-Prescott (2016), Blandin (2016),...

  study reforms in limited set of instruments, not necessarily optimal

- **Optimal taxation: (Ramsey approach)** Conesa-Krueger (2006), Heathcote et al. (2014), ... **(Mirrlees approach:)** Huggett-Parra (2010), Fukushima (2011), Heathcote-Tsujiyama (2015), Weinzierl (2011), Golosov et al. (forthcoming), Farhi-Werning (2013), Golosov-Tsyvinski (2006), Shourideh-Troshkin (2015), Bellofatto (2015)

  maximize social welfare $\Rightarrow$ mix redistribution with improving efficiency

- **Pareto efficient taxation:** Werning (2007)

  theoretical framework, static model

- **Imperfect annuity market and the effect of social security:** Hubbard-Judd (1987), Hong and Rios-Rull (2007), Hosseini (2015), Caliendo et al. (2014), ...

  social security does not provide large efficiency gains

Plan of the Talk

- Basic framework
  - Two-period OLG model
  - Theoretical results
- Quantitative life cycle model
- Calibration
- Quantitative exercise
- Conclusion

Basic Framework

Individuals

- A cohort is born each period
  - people are alive for at most 2 periods
  - draw ability type θ from distribution $F(\theta)$
- Individual of type θ
  - produces $y = \theta \cdot l$ if puts in l units of effort
  - survives to second period with probability $P(\theta)$
- Assumption: $P'(\theta) > 0$

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- Assumption: $P'(\theta) > 0$
- Important: government policies cannot depend on θ

Individual Optimization Problem

- Individual θ solves

$$\max u(c_1) + \beta P(\theta) u(c_2) - v\left(\frac{y}{\theta}\right)$$

s.t.

$$\begin{aligned} c_1 + a &= w_t y - T_y(w_t y) \\ c_2 &= (1 + r_{t+1}) a - T_a((1 + r_{t+1}) a, w_t y) \end{aligned}$$

- $T_y(\cdot)$ and $T_a(\cdot, \cdot)$ are increasing smooth tax functions
- There is no annuity market

  $\Rightarrow$ individuals may die with positive assets

- These assets are redistributed among those who are alive

No Free Lunch

Proposition

Status quo policy $\left\{T_y^{SQ}(\cdot), T_a^{SQ}(\cdot,\cdot)\right\}$*, is Pareto efficient iff it solves*

$$\min_{T_y(\cdot),T_a(\cdot,\cdot)} \int \left(c_1^t\left(T_y, T_a;\theta\right) + P\left(\theta\right)\frac{c_2^t\left(T_y, T_a;\theta\right)}{1+r_{t+1}} - w_t y^t\left(T_y, T_a;\theta\right)\right) dF\left(\theta\right)$$

s.t.

$$W^t\left(T_y, T_a;\theta\right) \geq W^t\left(T_y^{SQ}, T_a^{SQ};\theta\right), \quad \forall\theta$$

for all t.

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$$W^t\left(T_y, T_a; \theta\right) \geq W^t\left(T_y^{SQ}, T_a^{SQ}; \theta\right), \quad \forall \theta$$

for all t.

If Status quo policy $\left\{T_y^{SQ}(\cdot), T_a^{SQ}(\cdot,\cdot)\right\}$ is not pareto efficient, then a Pareto-improving reform exits

Examples

- Example 1: classic Diamond (1965)
  - no heterogeneity in ability ($F(\theta)$ is degenerate)
  - no survival risk ($P(\theta)$=1)
  - T_y^{SQ} and T_a^{SQ} are lump-sum taxes

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$\Rightarrow$ Status quo policies are Pareto efficient

Examples

- Example 2: Conesa and Garriga (2008)
  - no heterogeneity in ability ($F(\theta)$ is degenerate)
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  - $T_y^{SQ}(y) = T_0 + \tau_y y$ and T_a^{SQ} is lump-sum

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$\Rightarrow$ Replacing distortionary taxes by lump-sum improves efficiency

Important: there are no distributional concerns

Examples

- Example 3: this paper
  - heterogeneity in ability and mortality ($F(\theta)$ is not degenerate)
  - there is survival risk ($P(\theta) < 1$)
  - $T_y^{SQ}(y)$ and T_a^{SQ} are non-linear functions (distortionary taxes)

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  - $T_y^{SQ}(y)$ and T_a^{SQ} are non-linear functions (distortionary taxes)
- It is not clear reducing distortions will improve efficiency
- There is efficiency vs. equity trade off

Pareto Optimal Reform

$$\min_{T_y(\cdot),T_a(\cdot,\cdot)} \int \left(c_1(\theta) + \frac{P(\theta)c_2(\theta)}{1+r_{t+1}} - w_t y(\theta) \right) dF(\theta)$$

s.t.

$(c_1(\theta), c_2(\theta), y(\theta))$ is solution to

$$\begin{aligned} V(\theta) &= \max u(c_1) + \beta P(\theta) u(c_2) - v\left(\frac{y}{\theta}\right) \\ &\text{s.t.} \\ c_1 + a &= w_t y - T_y(w_t y) \\ c_2 &= (1+r_{t+1})\, a - T_a((1+r_{t+1})\, a, w_t y) \end{aligned}$$

$$V(\theta) \geq W^t \left(T_y^{SQ}, T_a^{SQ}; \theta \right)$$

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we can replace this whole box by envelope condition w.r.t θ

$$V(\theta) \geq W^t\left(T_y^{SQ}, T_a^{SQ}; \theta\right)$$

Pareto Optimal Reform

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This is *implementability* constraint

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$$V'(\theta) = \frac{y(\theta)}{\theta^2} v'\left(\frac{y(\theta)}{\theta}\right) + \beta P'(\theta) u(c_2(\theta))$$

first term is standard, second term is new

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We can solve this problem for allocations $c_1(\theta), c_2(\theta), y(\theta)\ \forall\ \theta$

From Allocations to Taxes

- Solving the planning problem will give us Pareto efficient allocations

- Using allocations we can back out (optimal) marginal taxes

$$1-\tau_y(\theta) \equiv 1-T'_y = \frac{1}{w_t\theta}\frac{v'\left(y/\theta\right)}{u'(c_1)}$$
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- We can also test whether any arbitrary set of taxes are optimal

Optimality of Earning Taxes

$$U(c_1, c_2, y/\theta) = u(c_1) - \psi \frac{(y/\theta)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} + \beta P(\theta) u(c_2)$$

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An arbitrary labor tax function is efficient iff

$$1 \geq -\theta \frac{\tau_y(\theta)}{1-\tau_y(\theta)} \frac{\epsilon}{1+\epsilon} \left[\frac{f'(\theta)}{f(\theta)} + \frac{1}{\theta} + \frac{\tau_y'(\theta)}{\tau_y(\theta)\left(1-\tau_y(\theta)\right)} + \sigma \frac{c_1'(\theta)}{c_1(\theta)} \right]$$

- This inequality is more likely to be violated if
  - $\frac{f'(\theta)}{f(\theta)}$ is negative (e.g, right tail of the distribution)
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  - labor supply is very elastic

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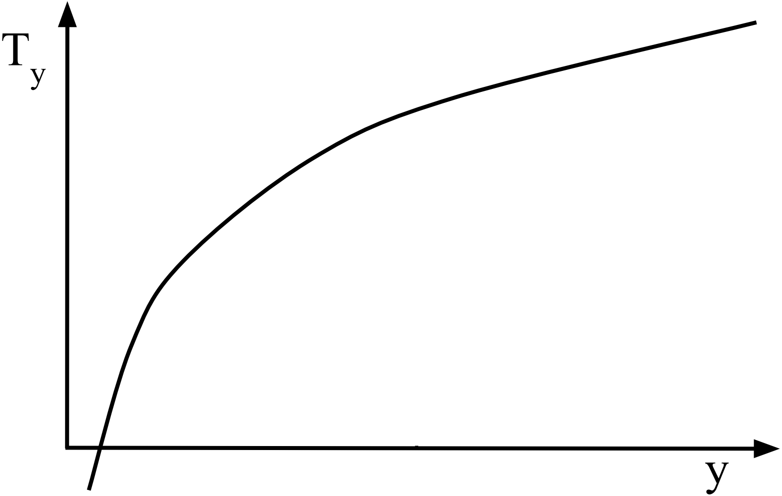
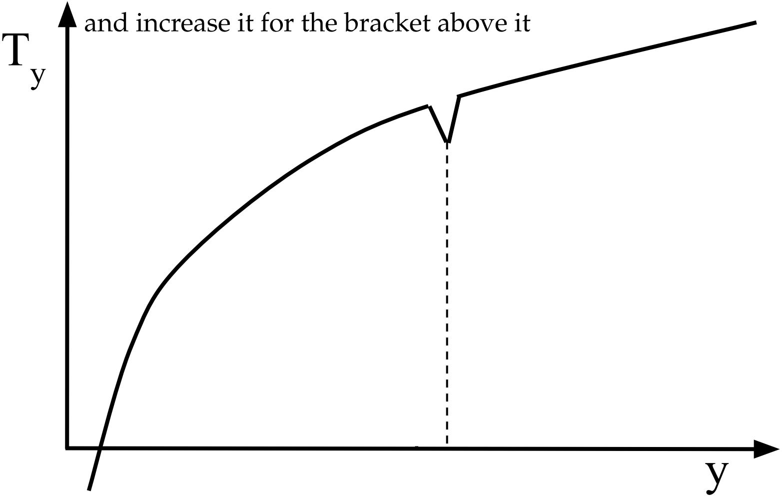
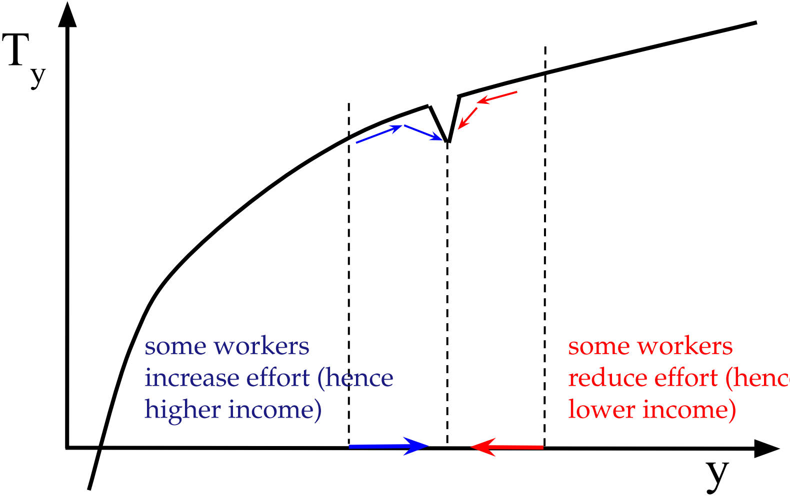
suppose tax code consists of tiny tax brackets



suppose we lower marginal tax for a bracket
and increase it for the bracket above it



this affects work effort in adjacent brackets



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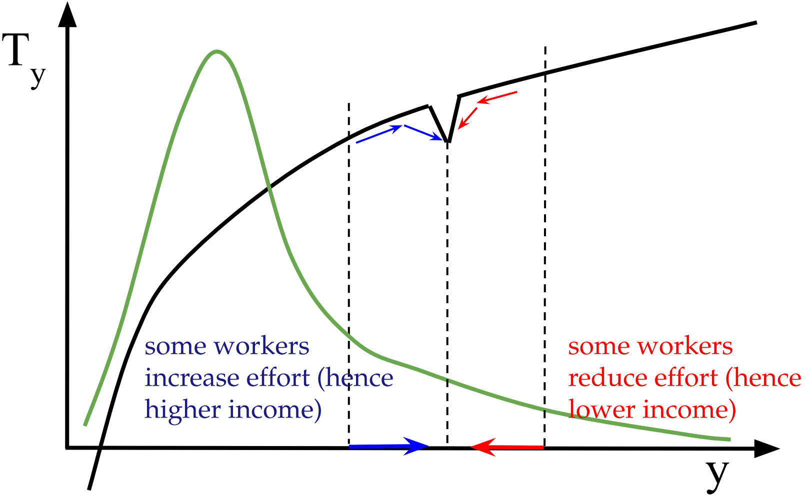
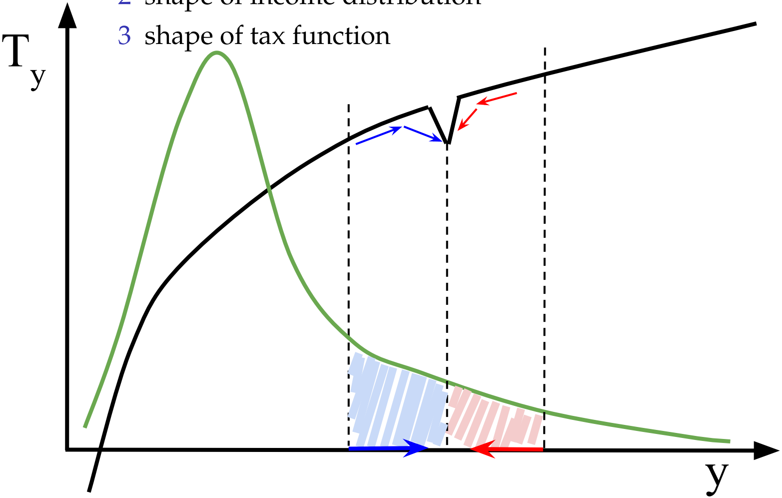
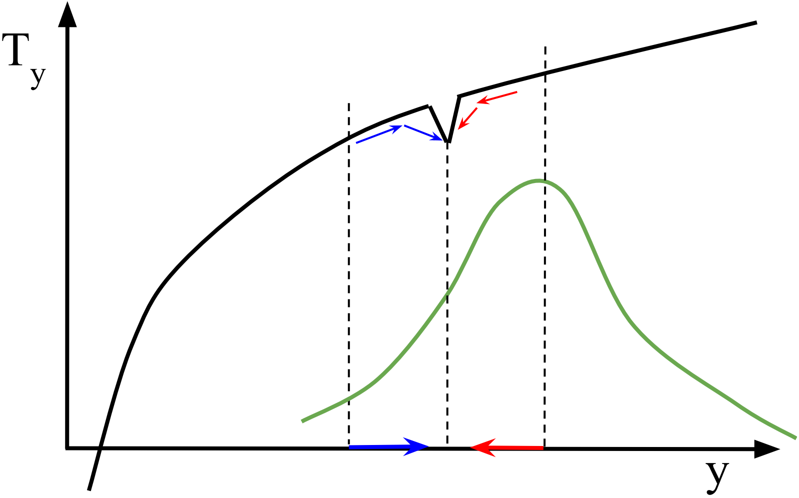


whether this raises revenue depends on:

1. strength of behavioral responses (elasticity)
2. shape of income distribution
3. shape of tax function





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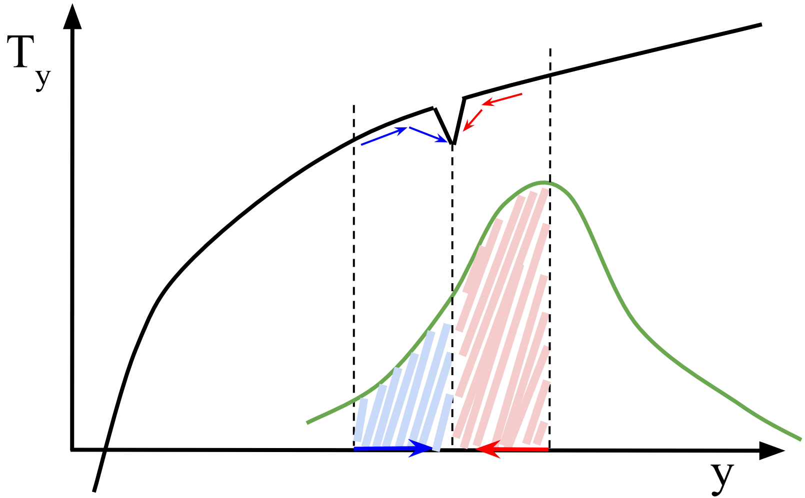
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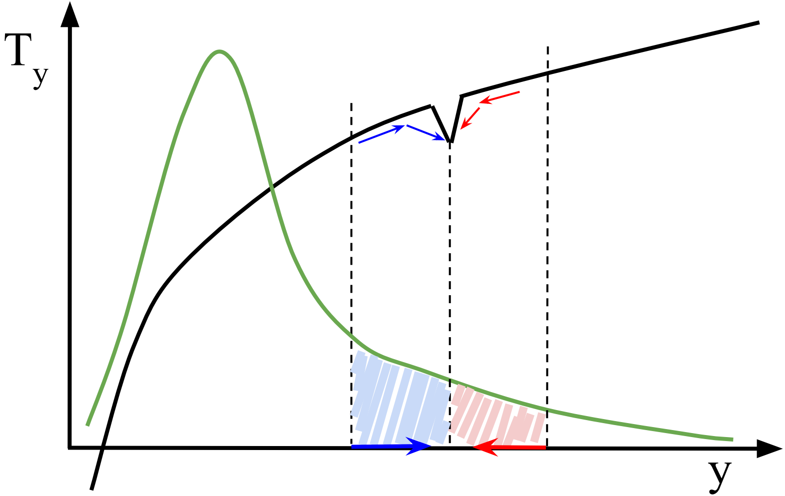
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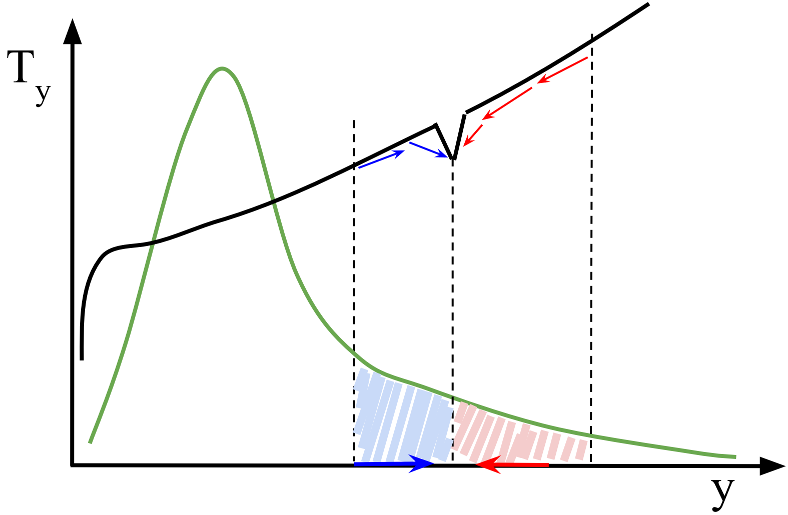

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y

Two Reasons To Distort Saving Decisions

1 - missing annuity market

- Suppose individual could purchase annuities at price q. Then

$$q \cdot u'(c_1) = P(\theta) \cdot (1+r)\beta u'(c_2)$$

▸ Example

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- In the absence of annuity market $q = 1$

$$u'(c_1) = P(\theta) \cdot (1+r)\beta u'(c_2)$$

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1 - missing annuity market

- Suppose individual could purchase annuities at price q. Then

$$q \cdot u'(c_1) = P(\theta) \cdot (1+r)\beta u'(c_2)$$

- If there are no market imperfections $q = P(\theta)$

$$u'(c_1) = (1+r)\beta u'(c_2)$$

- In the absence of annuity market $q = 1$

$$u'(c_1) = (1-\tau_a) \cdot P(\theta) \cdot (1+r)\beta u'(c_2)$$

A corrective tax

$$1 - \tau_a = \frac{1}{P(\theta)}$$

can restore efficiency

Example

Two Reasons To Distort Saving Decisions

2 - incentive provision

- Consider the following – extreme – example
  - Two individuals: high ability and low ability
  - High ability type survives with probability 1
  - Low ability type does not survive

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  - Low ability type does not survive

- Tension:

  want to deliver utils to low ability

  while preventing high ability from shirking

- Best solution: 100% savings tax for low income
  - prevents high ability from shirking
  - does not hurt low ability

Optimality of Asset Taxes

$$U(c_1, c_2, y/\theta) = u(c_1) - \psi \frac{(y/\theta)^{1+\frac{1}{\epsilon}}}{1+\frac{1}{\epsilon}} + \beta P(\theta) u(c_2)$$

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Proposition

Asset tax is efficient iff

$$P(\theta)(1-\tau_a(\theta)) = 1 - \frac{\theta}{1+1/\epsilon} \frac{\tau_y(\theta)}{1-\tau_y(\theta)} \frac{P'(\theta)}{P(\theta)}$$

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- This term corrects inefficiency due to absence of annuities
- This term reduces the cost of incentive provision
  - lower abilities puts less value on future consumption
  - taxing their future consumption, prevents shirking by higher ability

Summary

- Tax reform can be Pareto improving

  if there are within-generation inefficiencies

- How much efficiency can be gained by
  - Reforming labor income tax and transfer systems?
  - Introducing asset taxes that

    remedy lack of annuity market?

    improve incentive provision in the tax system?

- To answer these questions we need a quantitative model

Life-Cycle Framework

Individuals

- Large number of finitely lived individuals born each period
  - Population grows at constant rate n
  - There is a maximum age T
- Individuals are indexed by their type θ:
  - Drawn from distribution $F(\theta)$
  - Fixed through their lifetime
- Individual of type θ has
  - deterministic earnings ability $\varphi_t(\theta)$ at age t ($y_t = \varphi_t(\theta) l_t$)
  - survival rate $p_{t+1}(\theta)$ at age t
  - discount factor $\beta(\theta)$
- Assumption: $\beta'(\theta) > 0$, $\varphi_t'(\theta) > 0$ and $p_{t+1}'(\theta) > 0$ for all t, θ

Preferences and Technology

- Individual θ has preference over consumption and leisure

$$\sum_{t=0}^{T} \beta(\theta)^t P_t(\theta)\left[u(c_t) - v(l_t)\right]$$

where $P_t(\theta) = \Pi_{s=0}^{t} p_s(\theta)$

- Everyone retires at age R: $\varphi_t(\theta) = 0$ for $t > R$ for all θ

- Aggregate production function

$$Y = f(K, L)$$

Markets and Government

- There is no annuity, only risk free assets
  - upon death, the risk-free assets convert to bequest
  - bequest is transferred equality to all individuals alive

- Government
  - Collects taxes on labor earnings, consumption and corporate profit
  - Makes transfers to individuals in pre- and post- retirement ages
  - Makes exogenously given purchases

- Budget constraint of the government

$$G + (r - n)D + \textit{All Transfers} = \textit{All Taxes}$$

Individual Optimization Problem

- Individual of type θ solves

$$V(\theta) = \max \sum_{t=0}^{T} \beta(\theta)^t P_t(\theta) \left[u(c_t) - v\left(\frac{y_t}{\varphi_t(\theta)}\right)\right]$$

  subject to

$$(1+\tau_c)c_t + a_{t+1} = (1+r)a_t - T_a\left((1+r)a_t\right) + wy_t - T_y\left(wy_t\right) + Tr_t + SS_t\left(E_t\right)$$

- E_t is earnings history

- There is a corporate profit tax τ_K (paid by firms)

$$r = (1-\tau_K)(F_K - \delta)$$

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$$r = (1-\tau_K)(F_K - \delta)$$

Calibration

Calibration

1. Parametrize and estimate earning ability $\varphi_t(\theta)$
2. Parametrize and calibrate model of mortality $P_t(\theta)$
3. Parametrize and calibrate US status quo policies
4. Parametrize and calibrate preference and technology

- We do 1, 2 and 3 independent of the model
- Use the model to do 4

Earning Ability Profiles

- Use labor income per hour as proxy for working ability (PSID)

- Assume

$$\varphi_t(\theta) = \theta + \tilde{\varphi}_t$$

with

$$\log \tilde{\varphi}_t = \xi_0 + \xi_1 t + \xi_2 t^2 + \xi_3 t^3$$

- θ has Pareto-LogNormal distribution w/ parameters (μ_θ,σ_θ,a_θ)

  $a_\theta = 3$ is tail parameter $\rightarrow$ standard

  $\sigma_\theta = 0.6$ is variance parameter $\rightarrow$ variance of log wage in CPS

  $\mu_\theta = -1/a_\theta$ is location parameter $\rightarrow$ normalization ($E(log(\theta)) = 0$)

Survival Profiles

- Assume Gompertz force of mortality hazard

$$\lambda_t(\theta) = \frac{\eta_0}{\theta^{\eta_1}} \left(\exp(\eta_2 t)/\eta_2 - 1\right)$$

and

$$P_t(\theta) = \exp(-\lambda_t(\theta))$$

η_1 which determines ability gradient

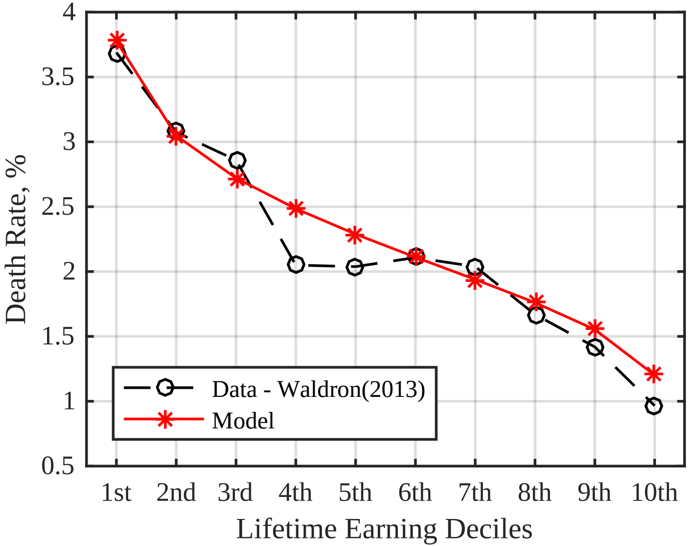
η_2 determines overall age pattern of mortality

η_0 is location parameter

- Use SSA's male mortality for 1940 birth cohort

- Use Waldron (2013) death rates (for ages 67-71)

Death Rates by Lifetime Earning Deciles

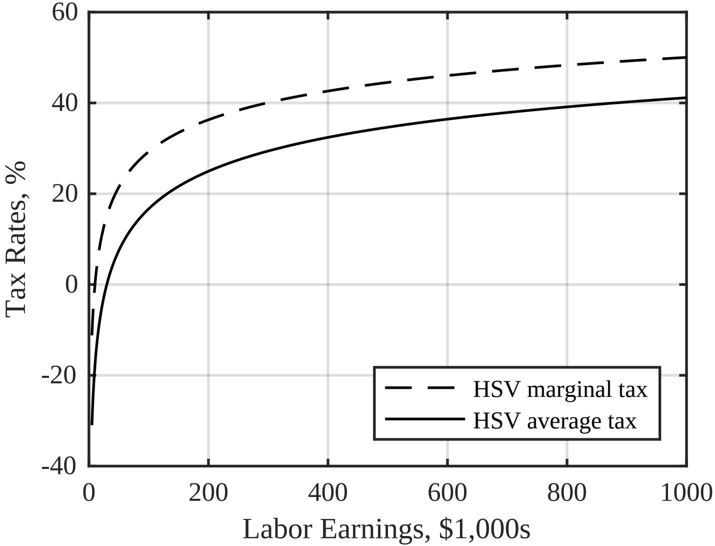


Status quo Government Policies

- Government collects four types of taxes
  - non-linear progressive tax on taxable income – we use
    $$\mathcal{T}(y) = y - \phi y^{1-\tau},$$
    the HSV tax function ($\tau = 0.151$, $\phi = 4.74$)
  - FICA payroll tax – we use SSA's tax rates
  - linear consumption tax – McDaniel (2007)
  - linear corporate/capital income tax (paid by firms) – 33%

- there is also a social security and Medicare benefit
  - Old-age: we use SSA's benefit formula
  - Medicare: 3% of GDP, paid equally to all retirees

Status quo Tax Function



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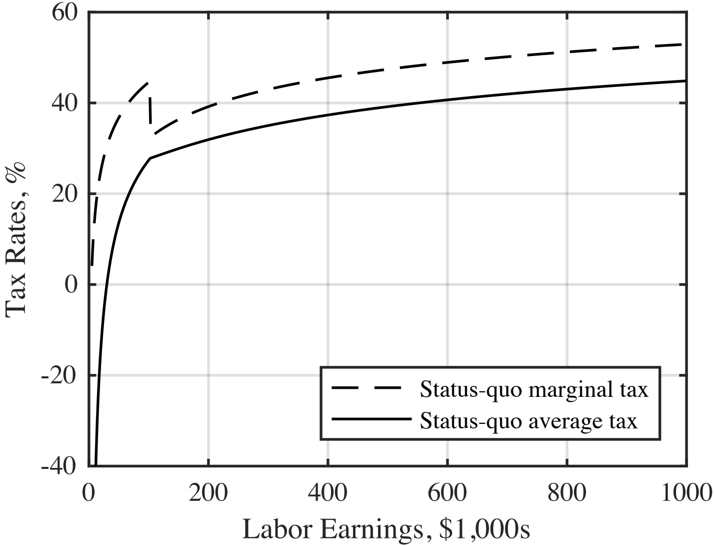

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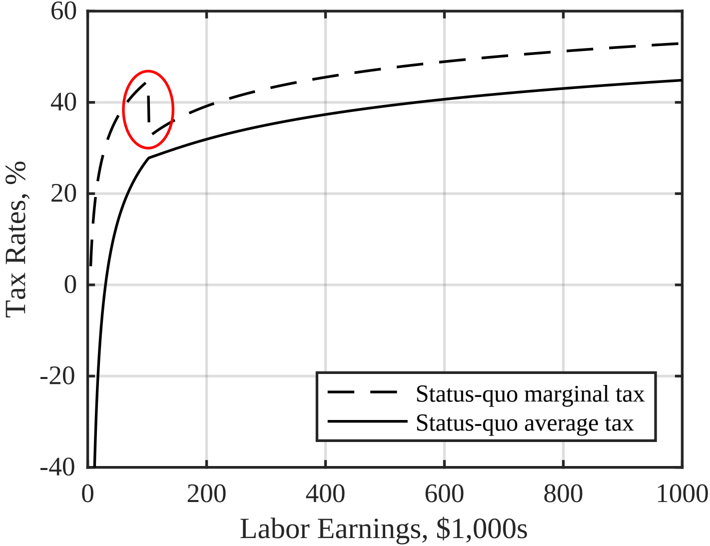

Preferences

- Utility over consumption and hours

$$u(c) - v(l) = \log(c) - \psi \frac{l^{1+\frac{1}{\epsilon}}}{1 + \frac{1}{\epsilon}}$$

  - Set $\epsilon = 0.5$
  - Choose ψ to match average hours per worker

- Fir discount factor, assume

$$\beta(\theta) = \beta_0 \cdot \theta^{\beta_1}$$

  - Choose β_0 to mach capital-output ratio
  - Choose β_1 to mach wealth gini

Calibration Summary
Parameters Calibrated Using the Model

Moments		Data	Model
Capital-output ratio		3	3
Wealth gini		0.78	0.78
Average annual hours		2000	2000
Parameter	**Description**		**Values/source**
$\bar{\beta}$	discount factor parameter		0.975
ω	discount factor parameter		0.01
ψ	weight on leisure		0.74

$$\beta(\theta) = \beta_0 \cdot \theta^{\beta_1}$$

Quantitative Analysis

Quantitative Exercise

- We can now use our calibrated model to
  1. Solve for status quo allocations
  2. Test optimality of stats quo policies
  3. Solve for optimal policies
  4. Measure efficiency gains from implementing optimal policies

- We first do this, holding fixed

  demographics

  prices (wages and interest rate)

  at current steady state level

Testing Earning Tax Schedule

$$1 \geq \underbrace{-\theta \frac{\tau_y(\theta)}{1-\tau_y(\theta)} \frac{\epsilon}{1+\epsilon}}_{A_t} \cdot \underbrace{\left[\frac{f'(\theta)}{f(\theta)} + \frac{1}{\theta} + \frac{\tau_y'(\theta)}{\tau_y(\theta)\left(1-\tau_y(\theta)\right)} + \sigma \frac{c_1'(\theta)}{c_1(\theta)}\right]}_{B}$$

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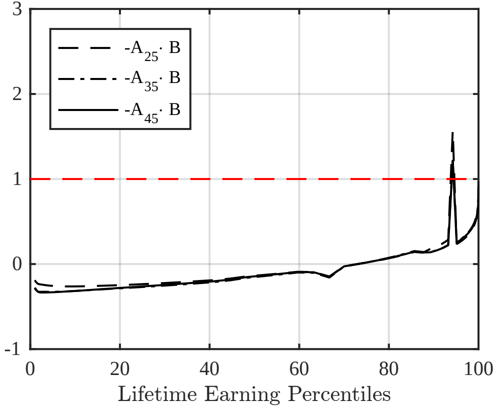

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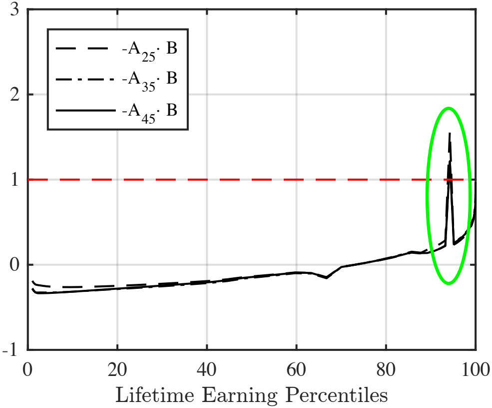

Testing Asset Tax

$$P(\theta)(1-\tau_a(\theta)) = \underbrace{1-\frac{\theta\epsilon}{1+\epsilon}\frac{\tau_y(\theta)}{1-\tau_y(\theta)}\left(\frac{\beta'(\theta)}{\beta(\theta)}+\frac{P'(\theta)}{P(\theta)}\right)}_{D_t}$$

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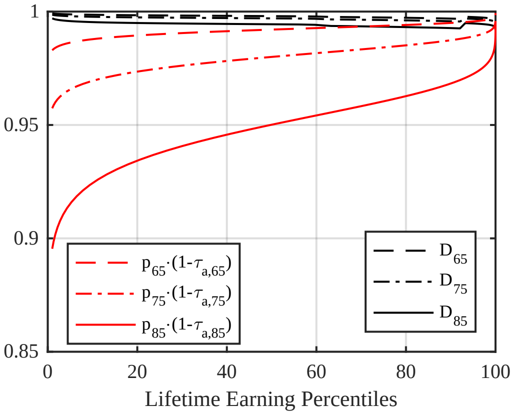
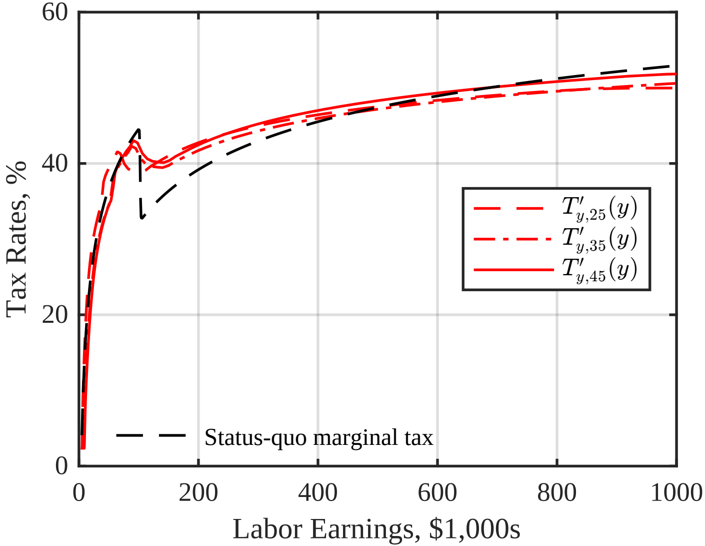
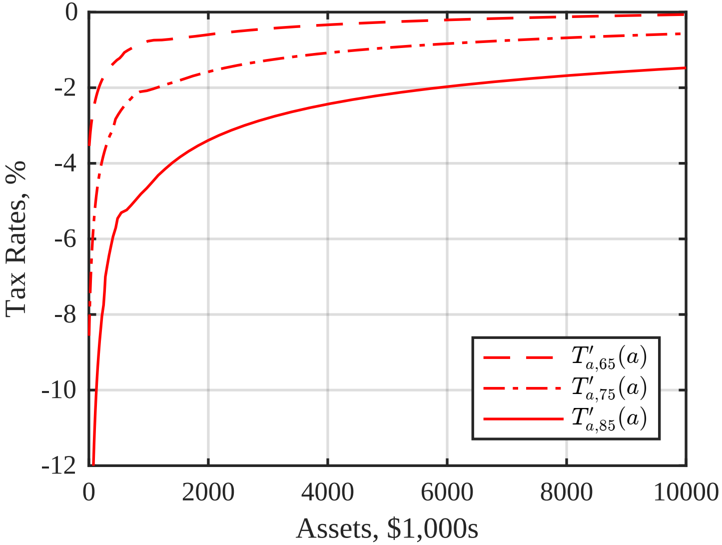


Optimal Earnings Tax



Optimal Asset Taxes (Subsidies)



Aggregate Effects

Shares of GDP	Status quo	Optimal
Consumption	0.70	0.67
Capital	3.00	3.43
Tax Revenue	0.25	0.26
Labor income tax	0.15	0.15
Consumption tax	0.04	0.04
Capital tax	0.06	0.07
Transfers	0.14	0.13
To retirees	0.09	0.03
To workers	0.05	0.03
Asset subsidy	0	0.07

PDV of net transfers to each cohort **falls** by 5.15%

How Important Are Asset Subsidies?

- Let's remove social security benefits and rule out asset subsidies

  and only reform earnings taxes

- What is the best that can be achieved?

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- The resulting allocations cost 2.25% **more** than status quo

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- What is the best that can be achieved?

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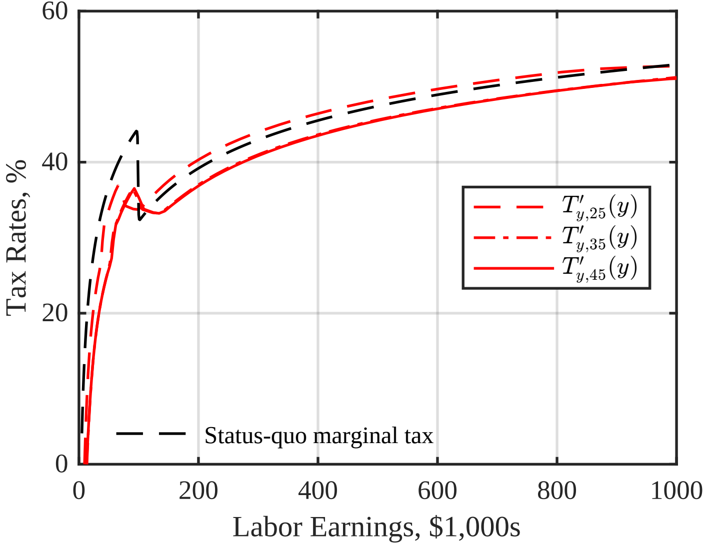
- Implication:

  IF proper asset subsidies are not in place,

  phasing out old-age transfers may not be a good idea!

Optimal Labor Income Taxes – No Asset Subsidies



Aggregate Effects

Shares of GDP	Status quo	Optimal	No Subsidy
Consumption	0.70	0.67	0.70
Capital	3.00	3.43	2.99
Tax Revenue	0.25	0.26	0.22
Labor income tax	0.15	0.15	0.12
Consumption tax	0.04	0.04	0.04
Capital tax	0.06	0.07	0.06
Transfers	0.14	0.13	0.04
To retirees	0.09	0.03	0.00
To workers	0.05	0.03	0.04
Asset subsidy	0.00	0.07	0.00

Optimal reform: PDV of net transfers to each cohort **falls** by 5.15%

No subsidy reform: PDV of net transfers to each cohort **rises** by 2.25%

Demographic Change – Continuation of Status quo

- We solve the model with
  - mortality of 2040 birth cohort
  - population growth of 0.5%
- Hold debt at 50% of GDP
- Adjust transfers to workers to balance the budget
- General equilibrium (endogenous w and r)
- Compute welfare for each generation along transition path

Demographic Change – Optimal Reform

- Anyone who is alive at the start of reform faces status quo policy
- For any other birth cohort we solve our cost min problem
- One time transfer to those who are alive in period 0

Demographic Change w/ Optimal Policies

Shares of GDP	Status quo Current Demog.	Status quo Future Demog.	Optimal Future Demog.
Consumption	0.70	0.70	0.70
Capital	3.00	3.23	3.28
Tax Revenue	0.25	0.25	0.24
Labor income tax	0.15	0.16	0.15
Consumption tax	0.04	0.04	0.04
Capital tax	0.06	0.05	0.05
Transfers	0.14	0.15	0.08
To retirees	0.09	0.14	0.03
To workers	0.05	0.01	-0.01
Asset subsidy	0.00	0.00	0.06
Interest rate (%)	4	3.4	3.3
Wage	1	1.04	1.05

Optimal reform: PDV of net transfers to each cohort **falls** by 4.9% Fig

Conclusion
Asset Subsidies?

- U.S. pays about 3% of GDP in asset subsidies
  - Tax deferred savings (401k, IRA, etc)
  - Tax beak for home ownership
  - Subsidies for small business development
- These subsidies:
  - Mostly affect richer individuals
  - Stop at retirement

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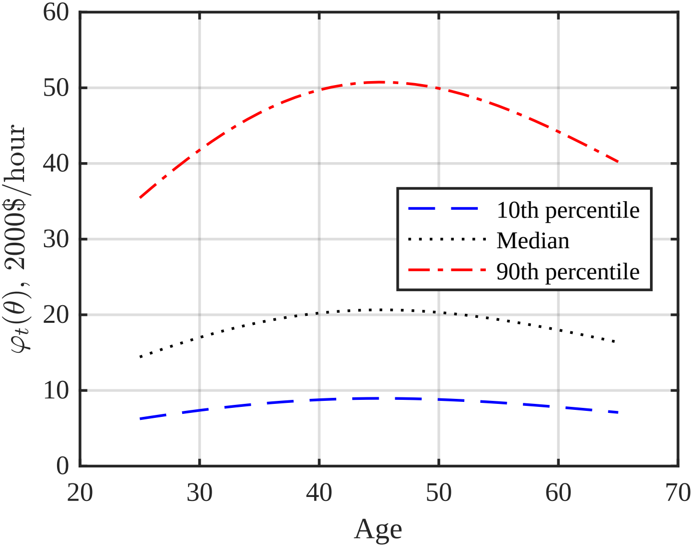
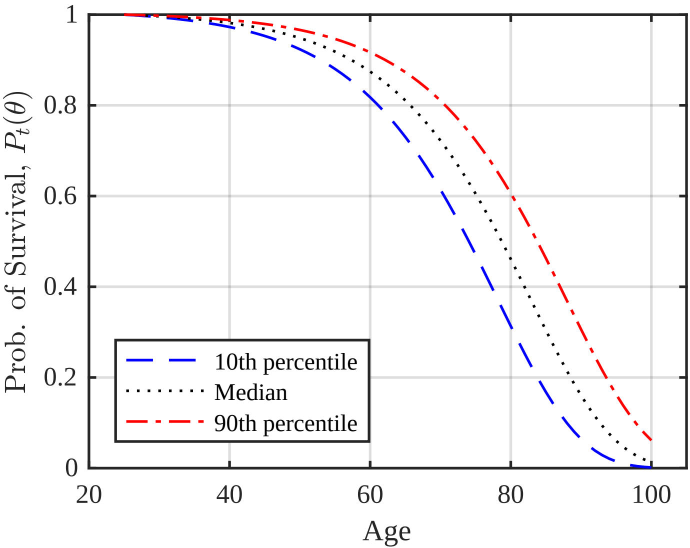
  - Tax deferred savings (401k, IRA, etc)
  - Tax beak for home ownership
  - Subsidies for small business development
- These subsidies:
  - Mostly affect richer individuals
  - Stop at retirement
- Contrast to optimal policies to current US system
  - Asset subsidies should not stop at retirement
  - Asset subsidies should be progressive

Back Up Slides

Earnings Ability Profiles



Unconditional Survival Probabilities

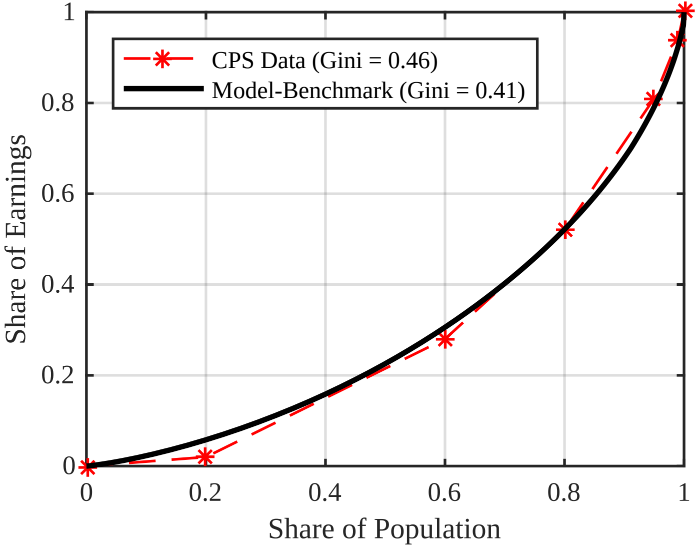


Calibration Summary

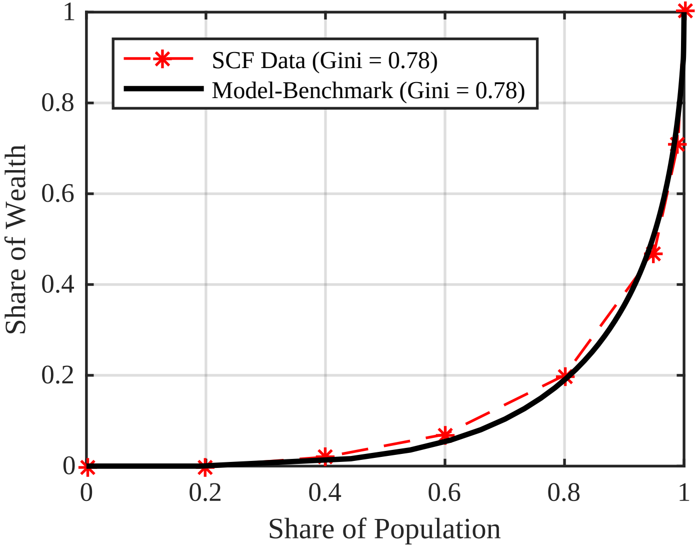
Parameters Chosen Outside the Model

Parameter	Description	Values/source
Demographics		
T	maximum age	75 (100 y/o)
R	retirement age	40 (65 y/o)
n	population growth rate	0.01
Preferences		
ϵ	elasticity of labor supply	0.5
Productivity		
$\sigma_\theta, a_\theta, \mu_\theta$	PLN parameters	0.5,3,-0.33
Technology		
α,δ	capital share and depreciation	0.36,0.06
Government policies		
$\tau_{ss}, \tau_{med}, \tau_c, \tau_K$	tax rates	0.124,0.029,0.055,0.33
G	government expenditure	$0.09 \times GDP$
D	government debt	$0.5 \times GDP$

Distribution of Earnings



Distribution of Wealth



Lack of Annuitization is Costly

perfect annuity

$$V^a = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + Pc_2 = 1$$

no annuity

$$V^{na} = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + c_2 = y$$

Lack of Annuitization is Costly

perfect annuity

$$V^a = \max \log c_1 + P \log c_2$$

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$$c_1 + Pc_2 = 1$$

$$\frac{1}{c_1} = \frac{1}{c_2}$$

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s.t.

$$c_1 + Pc_2 = 1$$

$$\Rightarrow c_1 = c_2 = \frac{1}{1+P}$$

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$$\Rightarrow V^a = -(1+P)\log(1+P)$$

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s.t.

$$c_1 + c_2 = y$$

$$\frac{1}{c_1} = P\frac{1}{c_2}$$

Lack of Annuitization is Costly

perfect annuity

$$V^a = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + Pc_2 = 1$$

$$\Rightarrow c_1 = c_2 = \frac{1}{1+P}$$

$$\Rightarrow V^a = -(1+P)\log(1+P)$$

no annuity

$$V^{na} = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + c_2 = y$$

$$\Rightarrow c_1 = \frac{y}{1+P}, c_2 = \frac{yP}{1+P}$$

Lack of Annuitization is Costly

perfect annuity

$$V^a = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + Pc_2 = 1$$

$$\Rightarrow c_1 = c_2 = \frac{1}{1+P}$$

$$\Rightarrow V^a = -(1+P)\log(1+P)$$

no annuity

$$V^{na} = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + c_2 = y$$

$$\Rightarrow c_1 = \frac{y}{1+P}, c_2 = \frac{yP}{1+P}$$

$$\begin{aligned} \Rightarrow V^{na} &= -(1+P)\log(1+P) \\ &\quad +(1+P)\log y + P\log P \end{aligned}$$

Lack of Annuitization is Costly

perfect annuity

$$V^a = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + Pc_2 = 1$$

$$\Rightarrow c_1 = c_2 = \frac{1}{1+P}$$

$$\Rightarrow V^a = -(1+P)\log(1+P)$$

no annuity

$$V^{na} = \max \log c_1 + P \log c_2$$

s.t.

$$c_1 + c_2 = y$$

$$\Rightarrow c_1 = \frac{y}{1+P}, c_2 = \frac{yP}{1+P}$$

$$\begin{aligned} \Rightarrow V^{na} &= -(1+P)\log(1+P) \\ &\quad +(1+P)\log y + P\log P \end{aligned}$$

To deliver same util $\Rightarrow \log y = -\frac{P}{1+P}\log P > 0$

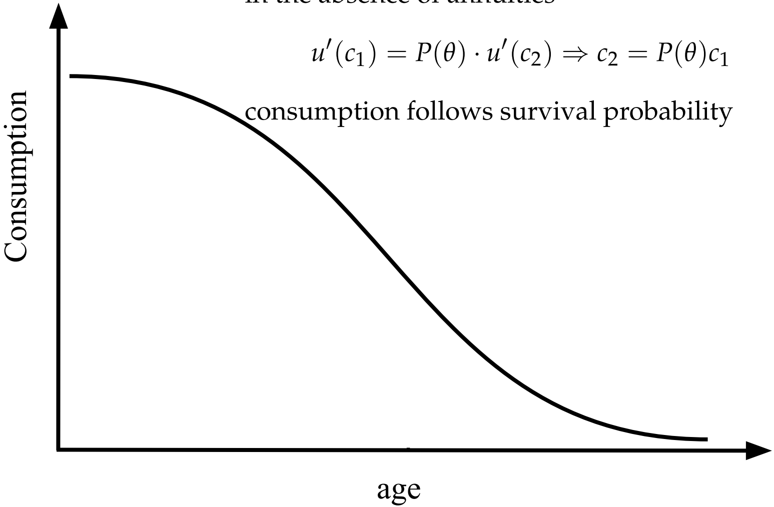
Lack of Annuitization is Costly

assume $\beta(1+r) = 1$ and log utility

in the absence of annuities

$$u'(c_1) = P(\theta) \cdot u'(c_2) \Rightarrow c_2 = P(\theta)c_1$$

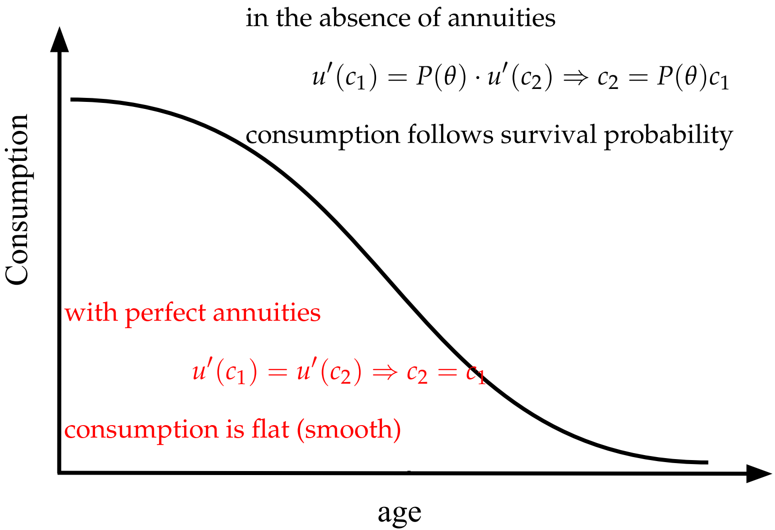
consumption follows survival probability



Go Back

Lack of Annuitization is Costly

assume $\beta(1+r) = 1$ and log utility



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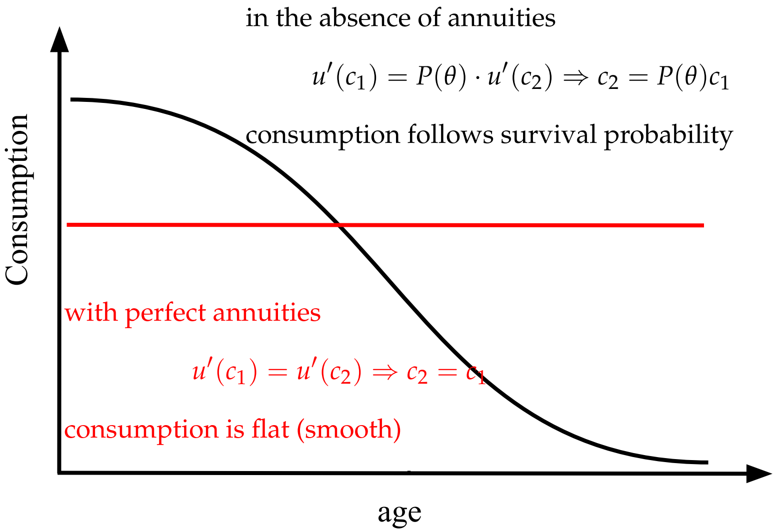
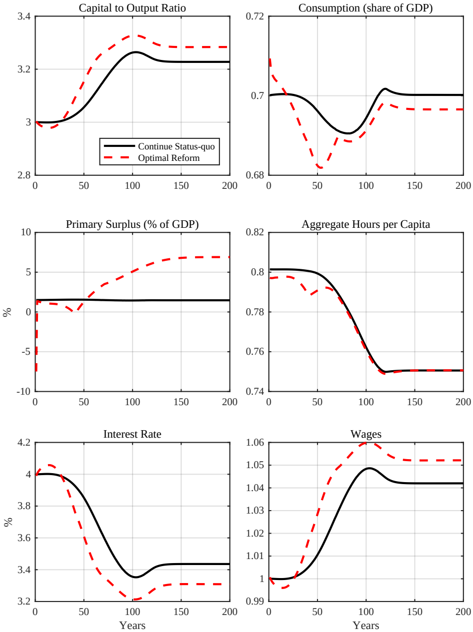
Lack of Annuitization is Costly

assume $\beta(1+r) = 1$ and log utility

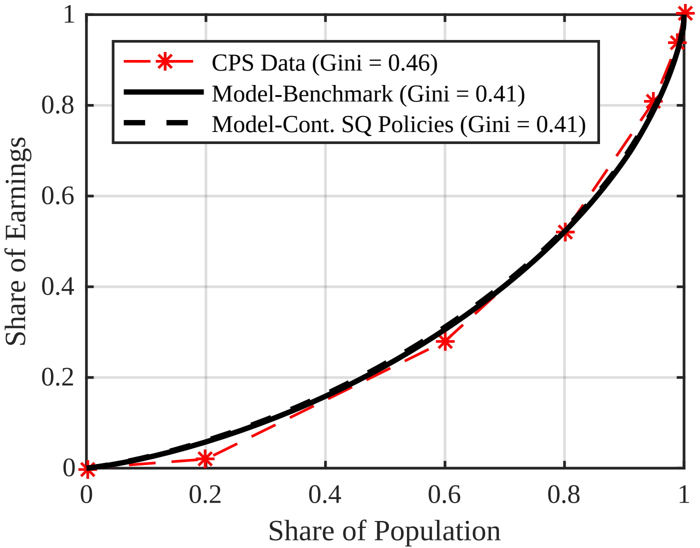


Go Back

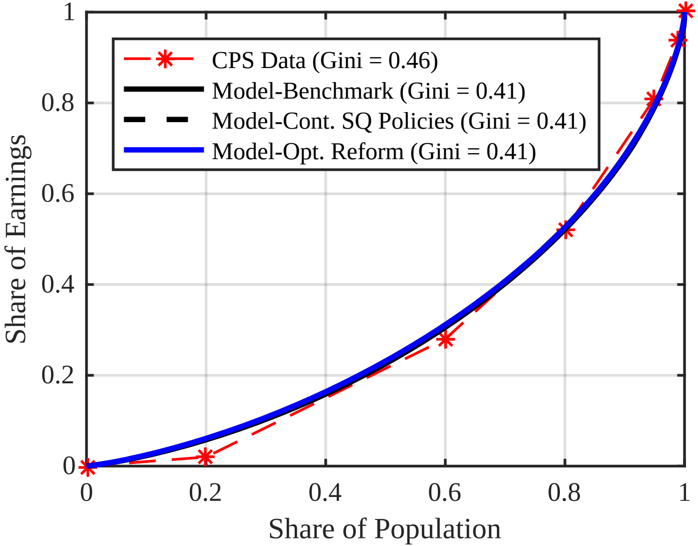
Transition - Macro Aggregates



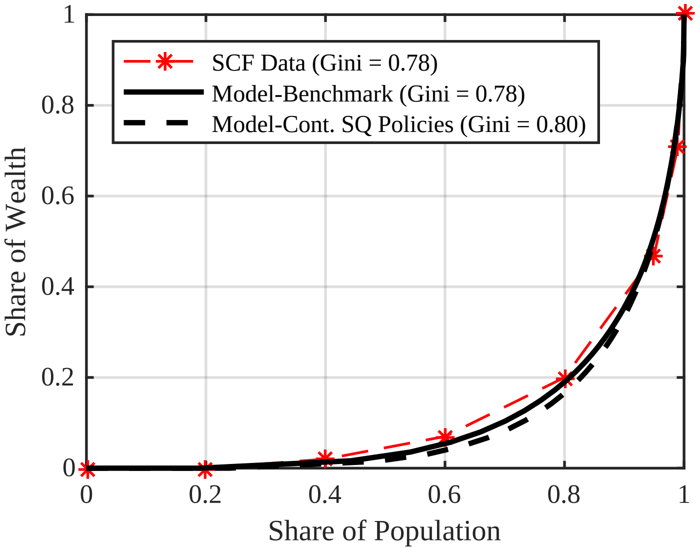
Distribution of Earnings w/ New Demographics



Distribution of Earnings w/ New Demographics



Distribution of Wealth w/ New Demographics



Distribution of Wealth w/ New Demographics