Optimal Progressivity with Age-Dependent Taxation

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How progressive should labor income taxation be?

• Arguments against progressivity: distortions
  ▶ Labor supply choice
  ▶ Human capital investment
How progressive should labor income taxation be?

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  ▶ Labor supply choice
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• Arguments in favor of progressivity: missing markets
  ▶ Unequal initial conditions
  ▶ Labor market shocks
  ▶ Increasing age-productivity profile

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
How progressive should labor income taxation be?

• Arguments against progressivity: distortions
  ▶ Labor supply choice
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• Arguments in favor of progressivity: missing markets
  ▶ Unequal initial conditions
  ▶ Labor market shocks
  ▶ Increasing age-productivity profile

• Q: Tagging → should optimal progressivity vary with age?
This paper

- OLG equilibrium model with:
  - flexible labor supply [static choice]
  - skill investment [dynamic choice]
  - differential disutility of work & learning ability [ex-ante heter.]
  - partial insurance against wage risk [ex-post uncertainty]
  - age profile for productivity and disutility of work [life cycle]
This paper

- **OLG equilibrium model** with:
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- **Baseline**: analytical model to isolate forces at work

- **Extension**: numerically solved model with borrowing and saving
TAX FUNCTION
Tax Function

\[ T(y) = y - \lambda y^{1-\tau} \]
Tax Function

\[ \log(y - T(y)) = \log \lambda + (1 - \tau) \log y \]
Tax Function

$$\log(y - T(y)) = \log \lambda + (1 - \tau) \log y$$

- It preserves analytical tractability
- It closely approximates U.S. tax/transfer system ($\tau^{US} = 0.181$)
We generalize tax/transfer system to allow for age variation:

\[ T_a(y) = y - \lambda_a y^{1-\tau_a} \]
Generalized Tax Function

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- Does the US tax/transfer system display age dependence?
Generalized Tax Function

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\[ T_a(y) = y - \lambda_a y^{1-\tau_a} \]

• Does the US tax/transfer system display age dependence?

• Estimate \( \{\tau_a\} \) by household age

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Related Literature


- **Efficiency profile**: Weinzierl (2009), Gorry and Oberfield (2012)

- **Uninsurable risk**: Farhi and Werning (2013), Golosov, Troshkin, and Tsyvinski (2016)

**HSV**: Transparency + GE + Transition + Quantitative
ENVIRONMENT
Preferences

- Preferences over consumption \((c)\), hours \((h)\), publicly-provided goods \((G)\), and skill-investment \((s)\) effort:

\[
U_i = -v_i(s_i) + \mathbb{E}_0 \sum_{a=0}^{A} \beta^a u_i(c_{ia}, h_{ia}, G)
\]
Preferences

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\]

\[
v_i(s_i) = \frac{1}{(\kappa_i)^{1/\psi}} \cdot \frac{s_i^{1+1/\psi}}{1 + 1/\psi}
\]

\[
\kappa_i \sim \text{Exp}(1)
\]
Preferences

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\[
u_i (c_{ia}, h_{ia}, G) = \log c_{ia} - \frac{\exp \left[ (1 + \sigma) (\varphi_{ia} + \bar{\varphi}_a) \right]}{1 + \sigma} (h_{ia})^{1+\sigma} + \chi \log G
\]

\[
\varphi_i \sim \mathcal{N} \left( \frac{v_{\varphi}}{2}, v_{\varphi} \right)
\]
Technology

- **Output** is a CES aggregator over continuum of skill types $s$:

  $$Y = \left[ \int_0^\infty N(s) \frac{\theta - 1}{\theta} ds \right]^{\frac{\theta}{\theta - 1}}, \quad \theta \in [1, \infty)$$

  - $N(s)$: effective hours of type $s$

- **Aggregate resource constraint**:

  $$Y = \sum_{a=0}^A \int_{i=0}^1 c_{i,a} \, di + G$$

  - WLOG: $G = gY$

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Individual Wages and Earnings

• Hourly wages:

\[
\log w_{ia} = \log p(s_i) + x_a + \alpha_{ia} + \varepsilon_{ia}
\]

▷ \(p(s_i)\): skill price = marginal product of labor of type \(s\)

▷ \(x_a\): deterministic age-productivity profile

▷ \(\alpha_{ia} = \alpha_{i,a-1} + \omega_{ia}, \quad \omega_{ia} \sim \mathcal{N}\left(-\frac{v_{\omega}}{2}, v_{\omega}\right)\) [uninsurable]

▷ \(\varepsilon_{ia} \sim iid \mathcal{N}\left(-\frac{v_{\varepsilon_a}}{2}, v_{\varepsilon_a}\right)\) [privately insurable]

• Gross earnings:

\[
y_{ia} = p(s_i) \times \exp(x_a) \times \exp(\alpha_{ia} + \varepsilon_{ia}) \times h_{ia}
\]

skill investment \quad life-cycle \quad shocks \quad labor supply
Government

- Government budget constraint (no government debt):

\[ gY = \sum_{a=0}^{A} \int_{0}^{1} \left[ y_i - \lambda_a y_i^{1-\tau_a} \right] \frac{dY_i}{T_a(y_i)} \]

- Government chooses vector \( \{ \lambda^*_a, \tau^*_a \} \) and \( g^* \)
Government

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- Government chooses vector \( \{ \lambda_a^*, \tau_a^* \} \) and \( g^* \)

  - Optimal public good provision: \( g^* = \frac{x}{1+\chi} \)

  - Samuelson condition: \( MRS_{C,G} = MRT_{C,G} = 1 \)
EQUILIBRIUM ALLOCATIONS
Skill Prices and Skill Investment

• Skill price has the **Mincerian form**:

\[ \log p(s) = \pi_0 + \pi_1 s(\kappa; \bar{\tau}) \]

• Closed form expressions for equilibrium \( \pi_0 \) and \( \pi_1 \)

• Optimal **skill investment** is linear in \( \kappa \):

\[ s(\kappa; \bar{\tau}) = \left[ (1 - \bar{\tau}) \pi_1 \right]^\psi \cdot \kappa \]

where:  
\[ \bar{\tau} = \frac{1 - \beta}{1 - \beta^{A+1}} \sum_{a=0}^{A} \beta^a \tau_a \]

• Distribution of \( p(s) \) is **Pareto** with parameter \( \theta \)

Heathcote-Storesetten-Violante, "Age-Dependent Taxation"
Consumption and Hours

$$\log c_a = \log \lambda_a + (1 - \tau_a) \left[ \frac{\log(1 - \tau_a)}{1 + \sigma} - (\varphi + \bar{\varphi}_a) + \log p(s) + x_a + \alpha \right] + C_a$$

- Progressivity determines the pass-through of shocks/inequality
Consumption and Hours

\[
\log c_a = \log \lambda_a + (1 - \tau_a) \left[ \frac{\log(1 - \tau_a)}{1 + \sigma} - (\varphi + \bar{\varphi}_a) + \log p(s) + x_a + \alpha \right] + C_a
\]

• Progressivity determines the pass-through of shocks/inequality

\[
\log h_a = \frac{\log(1 - \tau_a)}{1 + \sigma} - (\varphi + \bar{\varphi}_a) + \left( \frac{1 - \tau_a}{\sigma + \tau_a} \right) \varepsilon - \mathcal{H}_a
\]

• Log-utility → hours unaffected by \{\lambda_a, p(s), x_a, \alpha\}
Consumption and Hours

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\]

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- **Note**: insurable productivity shocks enters \(h\) but not \(c\)
SOCIAL WELFARE
Social Welfare Function

- **Utilitarian**: equal weight on welfare of all currently alive agents, discounts welfare of future cohorts at rate $\beta$

- $\beta = 1$: SWF equals steady-state welfare

- $\beta < 1$: SWF embeds transition as planner cares for past cohorts
  - Transition driven by irreversible skill choice of past cohorts
  - Allow $\{\lambda_{a,t}\}$, $\{\tau_{a,t}\}$, $g_t$ to vary freely by age and time
  - Initial condition: steady-state under $\tau^{US}$

- Feasible to optimize over large vector of policy parameters because social welfare has a closed-form
STEADY-STATE ANALYSIS
Social Welfare Function ($\beta = 1$)

$$W^{ss}(\{\tau_a\}) = -\frac{1}{A} \sum_{a=0}^{A-1} \frac{1 - \tau_a}{1 + \sigma}$$

Disutility of labor

$$+ \ (1 + \chi) \log \left[ \sum_{a=0}^{A-1} (1 - \tau_a)^{\frac{1}{1+\sigma}} \cdot \exp(x_a - \tilde{\varphi}_a) + \left( \frac{\tau_a (1 + \tilde{\sigma}_a)}{\tilde{\sigma}_a^2} + \frac{1}{\tilde{\sigma}_a} \right) \frac{v_{\varepsilon a}}{2} \right]$$

Gain from labor supply: effective hours $N$

$$+ \ (1 + \chi) \frac{1}{(1 + \psi)(\theta - 1)} \left[ \psi \log (1 - \bar{\tau}) + \log \left( \frac{1}{\eta \theta^\psi} \left( \frac{\theta}{\theta - 1} \right)^{\theta(1+\psi)} \right) \right]$$

Gain from skill investment: productivity: $\log(E[p(s)])$

$$- \ \frac{\psi}{1 + \psi} \frac{1 - \bar{\tau}}{\theta} + \frac{1}{A} \sum_{a=0}^{A-1} \left[ \log \left( 1 - \left( \frac{1 - \tau_a}{\theta} \right) \right) + \left( \frac{1 - \tau_a}{\theta} \right) \right]$$

Avg. skill inv. cost

$$- \ \frac{1}{A} \sum_{a=0}^{A-1} (1 - \tau_a)^2 \left( \frac{v_{\varphi}}{2} + a \frac{v_{\omega}}{2} \right)$$

Cons. dispersion due to unins. risk and pref. heter.

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
1. Optimal $\{\tau^*_a, \lambda^*_a\}$ are age-invariant if:

(a) $v_\omega = 0$: flat profile of uninsurable productivity dispersion

(b) $v_{\varepsilon a} = v_\varepsilon$: flat profile of insurable productivity dispersion

(c) $\{x_a - \bar{\varphi}_a\}$ constant: flat profile of efficiency net of disutility
Optimal Policy: Theoretical results for $\beta = 1$

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2. If, in addition, $\theta = \infty$ and $v_\varphi = 0$, the economy $\rightarrow$ RA and $\tau^*_a = -\chi$
   
   • Regressivity corrects the externality linked to valued $G$
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3. Given any profile for $\{\tau_a\}$, the optimal profile for $\{\lambda_a^*\}$ equates average consumption (i.e., the $MUC_a$) by age
Determinants of age profile of progressivity ($\beta = 1$)

(a) **Uninsurable Risk channel**

*Permanent uninsurable risk* ($v_{\omega} > 0$) implies that $\{\tau_a^*\}$ is increasing in age

(b) **Insurable Risk channel**

Starting from $\tau_a > 0$, rising insurable risk ($v_{\varepsilon,a+1} > v_{\varepsilon,a}$) implies that $\tau_{a+1}^* < \tau_a^*$

(c) **Life-Cycle channel**

Age profile in $\{x_a - \bar{\phi}_a\}$ implies $\{\tau_a^*\}$ which is its mirror image

- The optimal $\{\tau_a^*\}$ equates the labor wedge, $1 - MTR_a$, by age

$$1 - MTR_a = \lambda_a (1 - \tau_a) y^{\bar{a}}_{-\tau_a} = 1$$

- It implements the first best

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
PARAMETERIZATION
Parameterization

- Parameters: \( \{\tau^{US}, \chi, \sigma, \psi, \theta, v_\varphi, v_\omega, v_{\varepsilon 0}, v_\eta\} \) and \( \{x_a, \varphi_a\}_{a=1}^A \)

- US progressivity estimated on micro data \( \rightarrow \tau^{US} = 0.181 \)

- Assume observed \( G/Y = 0.19 = g^* \) \( \rightarrow \chi = 0.233 \)

- Frisch elasticity (micro-evidence \( \sim 0.5 \)) \( \rightarrow \sigma = 2 \)

- Price-elasticity of skill investment \( \rightarrow \psi = 0.65 \)

\[
\begin{align*}
var_0(\log c) & \rightarrow \theta = 3.12 \\
var(\log h) & \rightarrow v_\varphi = 0.035 \\
cov(\log w, \log c) & \rightarrow v_\omega = 0.0058 \\
cov(\log w, \log h) & \rightarrow v_{\varepsilon,0} = 0.09, \Delta v_{\varepsilon,a} = 0.0044
\end{align*}
\]

- \( \{x_a, \varphi_a\}_{a=1}^A \) estimated to match age profiles wages of and hours

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Age Profile for Efficiency and Disutility of Work

- Important: \( x_a - \bar{\varphi}_a \) is hump-shaped
Life-cycle Means and Variances

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Quantitative Results

\[ \beta = 1 \]
Representative Agent

- Optimality: $\tau_a^* = -\chi$

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Add Heterogeneity in Disutility of Work ($\varphi$)

- $\tau^*_a$ still flat but shifted up (redistribution) $\Rightarrow$ lower labor supply

Heathcote-Storesetten-Violante, "Age-Dependent Taxation"
Add Heterogeneity in Ability ($\theta$ finite)

- $\tau^*_a$ still flat but shifted further up (redistribution > distortion)

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Add Uninsurable Risk \( (\nu_\omega > 0) \)

- Profile for \( \tau^*_a \) steeper: more redistribution needed later in life since uninsurable risk cumulates
Add Insurable Risk ($\nu_\varepsilon > 0$)

- Profile for $\tau^*_a$ is flattened but still upward sloping
Add Life Cycle \( \{x_a, \bar{\varphi}_a\} \)

- \( x_a - \bar{\varphi}_a \) hump-shaped \( \Rightarrow \) earnings are hump-shaped
- \( \lambda_a \) is U-shaped to equalize consumption across ages
- Smoothing \( 1 - MTR_a = \lambda_a (1 - \tau_a) y_a^{1-\tau_a} \Rightarrow \tau_a \) is U-shaped as well
All Channels: Marginal Tax Rates by Age

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Age Varying Preferences for Consumption

- Use standard equivalence scale for household size to set desired consumption by age ⇒ age path for $u(c_a)$ shifter
Age Varying Preferences for Consumption

- Use standard equivalence scale for household size to set desired consumption by age → age path for $u(c_a)$ shifter

- Some consumption inequality over the life cycle is efficient → less redistribution through $\lambda_a$ and flatter profile for $\tau_a$
• Frisch at age 60 three times larger than at age 45 (Blundell et al.)

• It pushes optimal progressivity down at older ages
TRANSITIONAL DYNAMICS

\[ \beta < 1 \]
Optimal Policy with Transition

1. The optimal value for spending is $g_t = \frac{x}{1+\chi}$

2. Given any values for $\{\tau_{a,t}\}$, the optimal profiles $\{\lambda^*_{a,t}\}$ equate average consumption by age at each date $t$
Optimal Policy with Transition

1. The optimal value for spending is \( g_t = \frac{X}{1+\chi} \).

2. Given any values for \( \{\tau_{a,t}\} \), the optimal profiles \( \{\lambda_{a,t}^*\} \) equate average consumption by age at each date \( t \).

3. If (i) skill is the only source of heterogeneity and (ii) labor supply is inelastic, then optimal reform at \( t = 0 \) features:

   (a) \( \tau_{a,t}^* = 1 \) for all \( a > t \) (max expropriation from existing cohorts)

   (b) \( \tau_{0+j,t+j}^* = \tau_{0,t}^* < 1 \) for all \( j = 1, \ldots, A-1 \) and for all \( t \geq 0 \) (flat \( \tau_a \) profiles for the new cohorts)

Reminiscent of capital taxation, but progressivity varies by cohort, not time since human capital is non-tradable.
1. $\tau_a$ higher for existing cohorts: no skill investment distortion

2. $\tau_a$ rises with age: output grows, planner can redistribute more
Optimal Policy with Transition: Baseline

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Welfare Gains

- Equivalent variation: % of lifetime consumption
- Computed relative to the US tax/transfer system

<table>
<thead>
<tr>
<th>Benchmark</th>
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<th>Natural BL</th>
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Introducing Borrowing and Lending

- Modification to baseline model:
  - Non-contingent bonds in zero net supply s.t. credit limit
  - No insurable productivity risk
  - Tax levied on $y$ net of savings:

$$c_a = \lambda_a (wh + Rb - b')^{1-\tau_a}$$
Introducing Borrowing and Lending

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    \[ c_a = \lambda_a (wh + Rb - b')^{1-\tau_a} \]

- Numerical solution:
  - Skill investment decision rules still in closed form
  - Solve numerically for hours worked, savings, interest rate
  - Search for optimal $\{\tau_a\}$ as 2nd order polynomial of age
Estimation of Consumer Credit Limit

- **SCF 2013** data, households 25-60. We sum four components:
  
  (a) Limit on credit cards
  
  (b) Limit on HELOCs
  
  (c) \(2 \times\) installment loans for durables
  
  (d) \(2 \times\) other debt (e.g., short-term loans from IRA)
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Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
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- **We set it to $1.5 \times$ annual income** (90th percentile)

- **Zero BL** (tightest) $\Rightarrow$ autarky

- **Natural BL** (loosest): max 30 times annual income
Optimal Progressivity with Borrowing/Saving: $\beta R = 1$

- **Zero BL**: $\{\tau^*_a\}$ almost identical to benchmark model
- **Natural BL**: $\{\tau^*_a\}$ close to a model with flat profile for $\{x_a - \bar{\varphi}_a\}$
- **U.S. BL**: $\{\tau^*_a\}$ very similar to autarkity/benchmark case

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
• **Interest rate channel**: $\{\tau_a^*\}$ more downward sloping

  - $\beta R^* > 1$, but planner wants to equate $C_a$ across ages
  - $\lambda_a$ decreasing so that after tax interest rate is 1 (EE wedge)
  - $\tau_a$ also decreasing to equate labor wedge
Extension with Retirement and Pensions

- Disposable income in retirement: $\lambda_a [p(s_i) \exp(\alpha_{i,A} - \varphi_i)]^{1-\tau_a}$
Extension with Retirement and Pensions

• Disposable income in retirement: $\lambda_a \left[p(s_i) \exp(\alpha_i, A - \phi_i)\right]^{1-\tau_a}$

• Jump in $\tau_a$: no labor supply distortion in retirement

• Flat profile in retirement: no motive for age dependence

• No full compression: it would distort too much dynamic skill choice

• Lower $\tau_a$ during working life: skill choice depends on $\bar{\tau}$
Welfare Gains

- Equivalent variation: % of lifetime consumption
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Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
Lessons

• **Distinct roles** for $\lambda_a$ and $\tau_a$:
  - Tax level $\lambda_a$ delivers redistribution across age groups
  - Progressivity $\tau_a$ is key for skill investment and labor supply distortions, and for redistribution / insurance within age groups

• **Forces** shaping how progressivity varies with age **roughly offset**:
  - Uninsurable risk + sunk skill investment $\Rightarrow \tau_a$ rises with age
  - Rising labor productivity and insurable risk $\Rightarrow \tau_a$ falls with age

• **U-shape profile** for progressivity is optimal, but dampened if:
  - borrowing limits are very loose
  - preferences for consumption display a strong hump

Heathcote-Storesletten-Violante, "Age-Dependent Taxation"
THANKS!