The Importance of Modeling Income Taxes Over Time. U.S. Reforms and Outcomes

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U.S. Federal Income Taxes Change Frequently

- Quantify changes in effective federal income taxes over time
- Describe them and put them in historical context
- Evaluate to what extent they affect household behavior
- Argue that it is important to model tax variation over time (and its uncertainty)

What We Do

- Estimate effective tax functions for the U.S. using the PSID, 1969-2016
- Why?
  - They illustrate tax changes in a parsimonious way
  - They are a key input in structural models

More on What We Do

- U.S. taxation differs for single and married people
- Which effective tax functions do we estimate?
  - For a “Representative Decision Unit” (RDU)
    - Why? Parsimonious to discuss changes over time and single-agent household still most widely used model
  - For couples and singles separately
    - Why? Marital structure matters for taxation + heterogeneous responses to taxation

What Do We Do with These Tax Functions?

- Discuss tax changes over time
- Use those for couples and singles in a structural model
- Evaluate to what extent household behavior responds to tax regimes

What about the Model?

- Estimate quantitative life-cycle model of couples and singles
  - Matches key outcomes over the working period:
    - Labor market participation
    - Hours
    - Savings
  - Generates plausible elasticities of labor supply

Related Work Includes

- **Changes in taxes and economic outcomes**
  Romer and Romer (2010), Barro and Redlick (2011), Mertens and Montiel Olea (2018)

- **Approximating tax systems using effective tax functions**
  3 parameters: Gouveia and Strauss (1994), Guner, Kaygusuz, and Ventura (2014)
  2 parameters: Feldstein (1969), ..., Heathcote, Storesletten, and Violante (2017), Qiu and Russo (2022)

- **Taxation in structural models**
  - **Without time variation**
    Very long list...
  - **With time variation**
    Much shorter list, including Kaymak and Poschke (2016), Blundell, Costa-Dias, Goll, and Meghir (2021), Borella, De Nardi, and Yang (2022), Yu (2022)

The Effective Tax Functions

$$T(Y_t) = Y_t - (1 - \lambda_t) Y_t^{1-\tau_t}$$

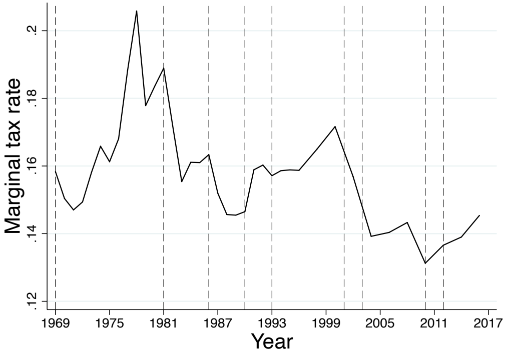
- Parameters:
  - $\Rightarrow$ λ_t = average level of taxation
  - $\Rightarrow$ τ_t = progressivity
- We estimate it year-by-year

▸ Tax Parameters ▸ Data and Income Definitions ▸ Sample Selection ▸ Estimation Details ▸ Fit

RDU Taxation over Time

- **RDU:** Abstracts from marital status
- Compute pre- and post-tax income at the household level for every household (whether married or single)
- Estimate tax function at the household level
- Display results for the RDU with median pre-tax income

What Do We Learn? RDU Taxation over Time



More Graphs

What Do We Learn? RDU Taxation over Time

- Large variation in average and marginal tax rates over time for median hh

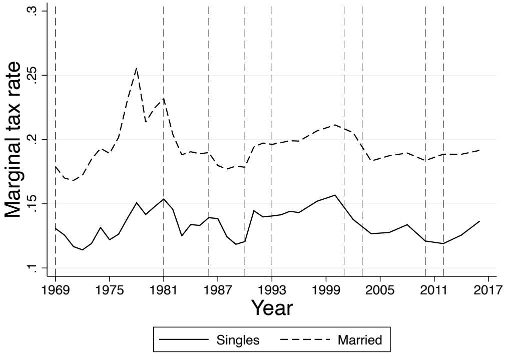
Rate	Minimum	Maximum
Average	6.7% in 2010	12.0% in 1978
Marginal	13.5% in 2010	21.0% in 1978

- 1970-1978: large increase in effective taxation, mostly due to increasing inflation
- 1978-1990: substantial tax decrease, mainly Reagan tax reforms
- 1990-2000: moderate increase, Bush Sr. and Clinton years
- 2000-2011: another large tax decrease, Bush tax cuts
- 2011-2016: Rebound in effective taxation, mostly due to Great recession recovery in income

Couples and Singles

- Separately compute household-level tax functions for single and married households
- Display results for median-income couples and median-income singles

What Do We Learn? Couples and Singles



More Graphs

What Do We Learn? Couples and singles

- Large variation in average and marginal tax rates within groups

Rate	Minimum	Maximum
	Couples	
Average	7.0% in 2010	13.4% in 1978
Marginal	16.9% in 1971	25.7% in 1978
	Singles	
Average	5.8% in 2010	8.9% in 1998
Marginal	11.6% in 1972	16.0% in 1981

- While levels of taxes are different, trends over time are similar

How Large Are These Tax Changes?

- Use a structural model to quantify effects of tax regimes on
  - ⇒ Labor market participation
  - ⇒ Hours worked
  - ⇒ Labor income
  - ⇒ Savings

Model Summary

- Single and married people
- Endogenous human capital formation (learning by doing)
- Working period: Wage, marriage, and divorce shocks
- Retirement: Health, medical expenses, and life span risk
- Self-insurance: saving and labor supply
- Government programs: Tax treatment of married and single people; Social Security payments with survivors and spousal benefits; Old-age means-tested transfers

▸ Wages ▸ Marriage ▸ Children ▸ Health Risk

Household Preferences

- β = discount factor
- Time endowment: $L^{i,j}$
- Leisure $l_t^{i,j} = L^{i,j} - n_t^{i,j} - \phi_t^{i,j} I_{n_t^{i,j}}$
- Singles

$$v^i(c_t, l_t, \eta_t^{i,1}) = \frac{((c_t/\eta_t^{i,1})^\omega l_t^{1-\omega})^{1-\gamma} - 1}{1-\gamma},$$

- Couples

$$w(c_t, l_t^1, l_t^2, \eta_t^{i,j}) = \frac{((c_t/\eta_t^{i,j})^\omega (l_t^1)^{1-\omega})^{1-\gamma} - 1}{1-\gamma} + \frac{((c_t/\eta_t^{i,j})^\omega (l_t^2)^{1-\omega})^{1-\gamma} - 1}{1-\gamma}$$

Recursive Problems

- Value functions for singles
  - ▸ Working period
  - ▸ Early retirement
  - ▸ Retirement
- Value functions for couples
  - ▸ Working period
  - ▸ Early retirement
  - ▸ Retirement
- Value functions for people in couples
  - ▸ People in couples

Recursive Problem for Working-Age Singles ($j = 1$)

$$W^s(t, i, a_t^i, \epsilon_t^i, \bar{y}_t^i) = \max_{c_t, a_{t+1}^i, n_t^i} \Bigg(v^i(c_t, l_t^{i,j}, \eta_t^{i,1}) +$$

$$\beta(1 - \nu_{t+1}(\cdot)) E_t W^s(t+1, i, a_{t+1}^i, \epsilon_{t+1}^i, \bar{y}_{t+1}^i) +$$

$$\beta \nu_{t+1}(\cdot) E_t \xi_{t+1}(\cdot) \theta_{t+1}(\cdot) \hat{W}^c(t+1, i, a_{t+1}^i + a_{t+1}^p, \epsilon_{t+1}^i, \epsilon_{t+1}^p, \bar{y}_{t+1}^i, \bar{y}_{t+1}^p) \Bigg)$$

- t : Age
- i : Gender
- a_t^i : Net worth from previous period
- ϵ_t^i : Current productivity shock
- $\bar{y}_t^i$: Annual accumulated Social Security earnings
- $\hat{W}^c$: Individual's discounted present value of being in a marriage ▸ People in couples

Recursive Problem for Working-Age Singles ($j = 1$)

Leisure	$l_t^{i,j} = L^{i,j} - n_t^i - \Phi_t^{i,j} I_{n_t^i}$
Earnings	$Y_t^i = e_t^i(\bar{y}_t^i)\epsilon_t^i n_t^i$
Tax	$T(\cdot) = T(ra_t^i + Y_t^i, i, j, t)$
Child care	$\tau_c(i,j,t) = \tau_c^{0,5} f^{0,5}(i,j,t) + \tau_c^{6,11} f^{6,11}(i,j,t)$
Budget	$c_t + a_{t+1}^i = (1+r)a_t^i + Y_t^i(1 - \tau_c(i,j,t)) - \tau_t^{SS} \min(Y_t^i, \widetilde{y}_t) - T(\cdot)$
Human capital	$\bar{y}_{t+1}^i = (\bar{y}_t^i(t - t_0) + (\min(Y_t^i, \widetilde{y}_t)))/(t + 1 - t_0)$

$$a_{t+1}^i \geq 0, \quad n_t^i \geq 0$$

Early retirement Retirement

Recursive Problem for Working-Age Couples ($j = 2$)

$$W^c(t, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = \max_{c_t, a_{t+1}, n_t^1, n_t^2} \Bigg(w(c_t, l_t^{1,j}, l_t^{2,j}, \eta_t^{i,j})$$
$$+(1 - \zeta_{t+1}(\cdot))\beta E_t W^c(t+1, a_{t+1}, \epsilon_{t+1}^1, \epsilon_{t+1}^2, \bar{y}_{t+1}^1, \bar{y}_{t+1}^2)$$
$$+\zeta_{t+1}(\cdot)\beta \sum_{i=1}^{2} \Big(E_t W^s(t+1, i, a_{t+1}/2, \epsilon_{t+1}^i, \bar{y}_{t+1}^i) \Big) \Bigg)$$

- t : Age
- a_t : Net worth from previous period
- ϵ_t^i : Current productivity shock for each spouse
- $\bar{y}_t^i$: Annual accumulated SS earnings for each spouse
- Divorce probability $\zeta_t(\cdot) = \zeta_t(\epsilon_t^1, \epsilon_t^2)$

Recursive Problem for Working-Age Couples ($j = 2$)

Leisure	$l_t^{i,j} = L^{i,j} - n_t^i - \Phi_t^{i,j} I_{n_t^i}$	$i = 1, 2$
Earnings	$Y_t^i = e_t^i(\bar{y}_t^i)\epsilon_t^i n_t^i$	$i = 1, 2$
Human capital	$\bar{y}_{t+1}^i = (\bar{y}_t^i(t - t_0) + (\min(Y_t^i, \widetilde{y}_t)))/(t + 1 - t_0)$	$i = 1, 2$
Tax	$T(\cdot) = T(ra_t + Y_t^1 + Y_t^2, i, j, t)$	
Child care	$\tau_c(i, j, t) = \tau_c^{0,5} f^{0,5}(i, j, t) + \tau_c^{6,11} f^{6,11}(i, j, t)$	$i = 2$

Budget

$$c_t + a_{t+1} = (1 + r)a_t + Y_t^1 + Y_t^2(1 - \tau_c(2, 2, t)) - \tau_t^{SS}(\min(Y_t^1, \widetilde{y}_t) + \min(Y_t^2, \widetilde{y}_t)) - T(\cdot)$$

$$a_{t+1} \geq 0, \quad n_t^1, n_t^2 \geq 0$$

Early retirement Retirement

How We Estimate the Model

- One cohort (born 1941-1945). HRS and PSID data
- Taxes vary over time as in the data + perfect foresight
- Over the working period, match
  - $\Rightarrow$ Labor market participation
  - $\Rightarrow$ Hours worked
  - $\Rightarrow$ Savings
- Obtain labor supply elasticities consistent with previous findings

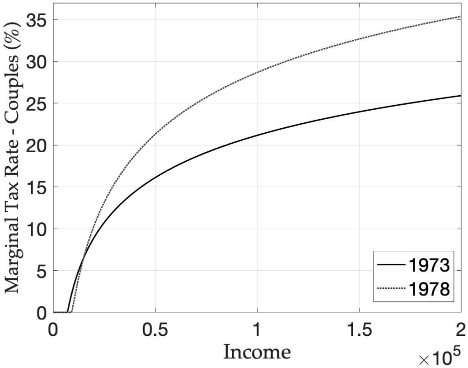
Estimation Strategy | Estimates | Fit | Elasticity

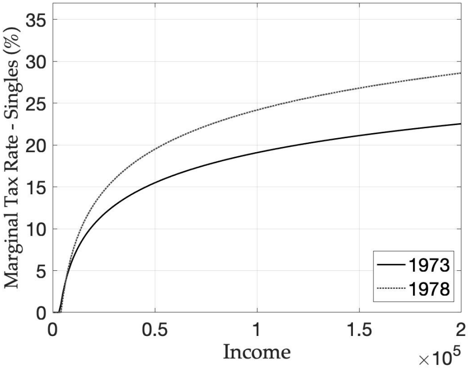
Evaluating Model Outcomes under Various Tax Regimes

Compare outcomes under

- Constant taxes over the life-cycle
  - ⇒ 1973 tax regime / 1978 tax regime (High inflation)
  - ⇒ 1980 tax regime / 1984 tax regime (Reagan tax cut)
- Constant taxes / time varying taxes
  - ⇒ 1969 tax regime / time varying

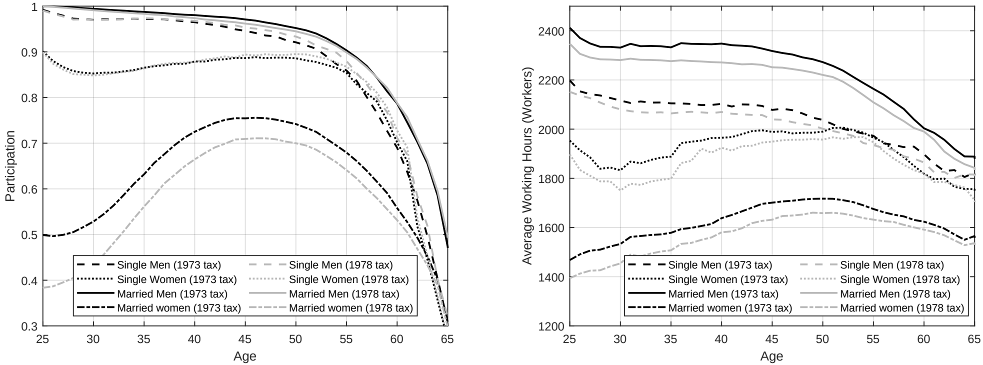
Comparing 1973 and 1978: the High Inflation Period





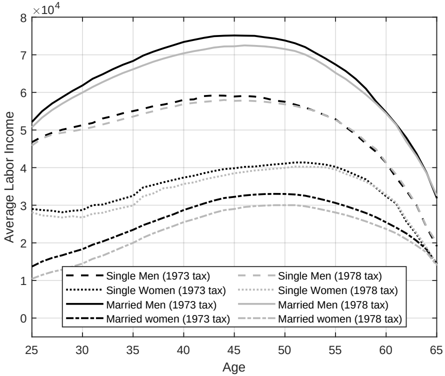
- Effective marginal tax rates for median-income couples ↑ 6.4 pp and for singles ↑ 2.9 pp
- High inflation rate + tax brackets not indexed + some tax reforms

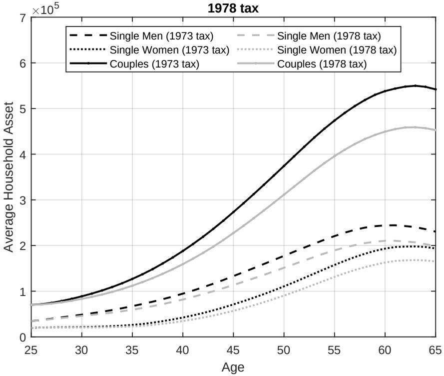
Comparing 1973 and 1978: Effects on Model Outcomes



- Participation of young married women ↓ by 9.4 pp
- Hours worked by workers ↓ over first 10 years by 5.1%, 2.4%, 4.5%, and 1.7% for married women and men, and single women and men

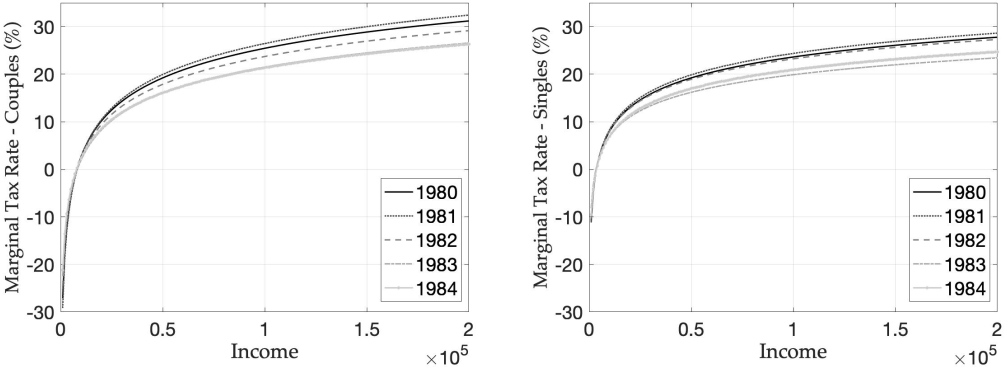
Comparing 1973 and 1978: Effects on Model Outcomes





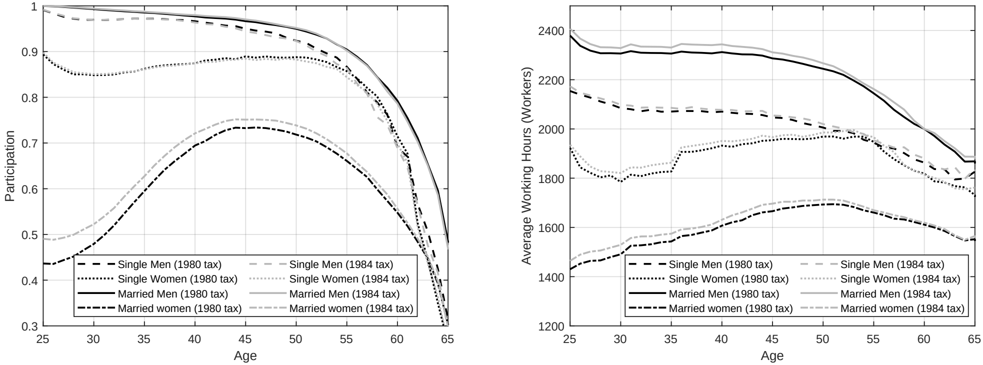
- Drops in participation and hours ⇒ large reductions in labor income: 20.2%, 3.1%, 6.2%, and 2.1%, for married women and men, and single women and men
- Decreases in labor income ⇒ substantial decreases in savings

Comparing 1980 and 1984: Reagan 1981 Tax Cut



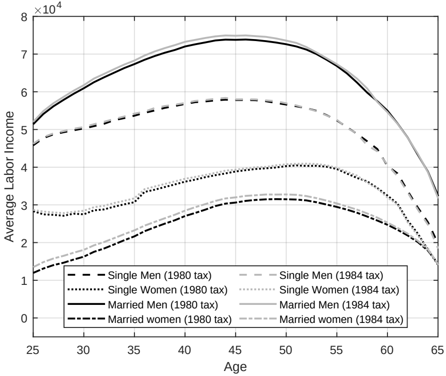
- Effective marginal tax rates for median-income couples ↓ 3.6 pp and for singles ↓ 1.8 pp

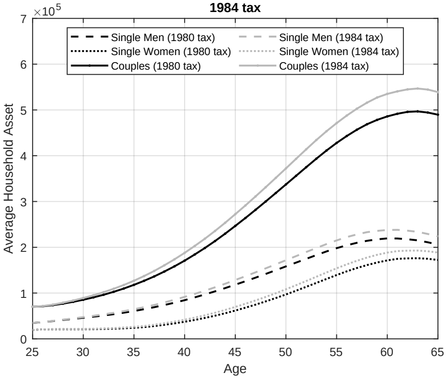
Comparing 1980 and 1984: Effects on Model Outcomes



- Participation of young married women ↑ 4.4 pp and 1.0 pp closer to retirement
- Hours worked by workers ↑ over first 10 years, by 2.4%, 1.1%, 1.9%, and 0.7% for married women and men, and single women and men

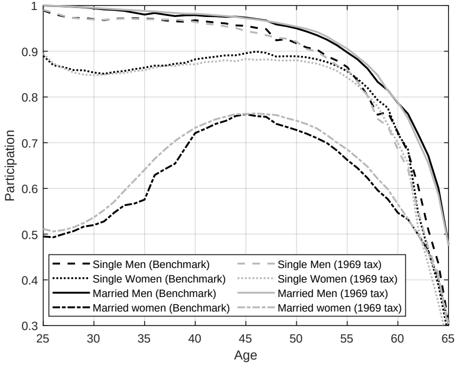
Comparing 1980 and 1984: Effects on Model Outcomes

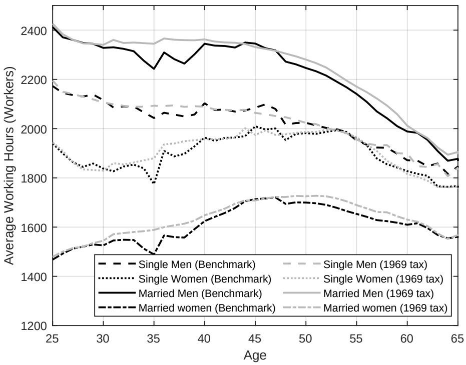




- Increases in participation and hours ⇒ large increase in labor income: 10.5%, 1.4%, 2.7%, and 0.8% for married women and men, and single women and men
- Higher in labor income ⇒ substantial increase in savings

Comparing 1969 Regime with Historically Realized Regimes: Model Outcomes

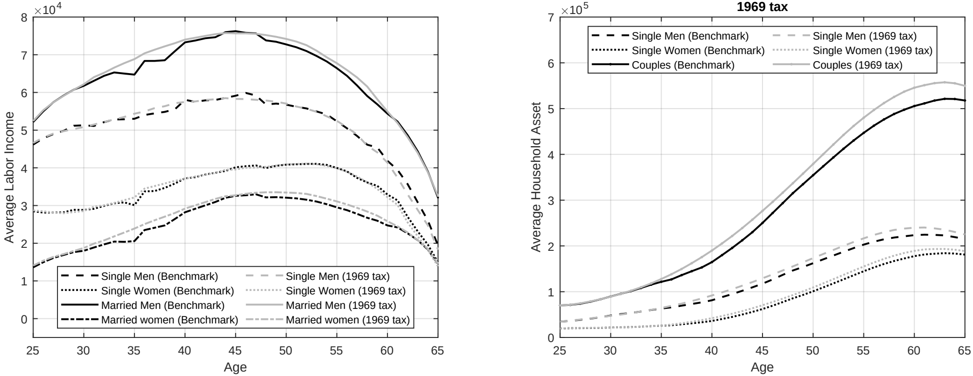




⇒ 1969 taxation: More participation, especially for married women, over most of their life cycle. 2pp higher on average

⇒ More hours worked (2% higher for married women and 1.5% for married men)

Comparing 1969 Regime with Historically Realized Regimes: Model Outcomes



⇒ 1969 taxes: Higher labor income (4% higher for married women)

⇒ More savings, especially for married couples

Conclusions

- Important variation in effective taxation over time
- Large effects on household behavior
- Important to model tax changes, including in structural model
- Important to also think about uncertainty about these tax changes

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Interpretation of tax parameters

- Average tax rate

$$\frac{T(Y)}{Y} = 1 - (1-\lambda)Y^{-\tau},$$

$\Rightarrow \lambda =$ average tax rate for $Y = 1$

- Elasticity of post-tax income with respect to pre-tax income:

$$\frac{\partial \log(Y - T(Y))}{\partial \log(Y)} = 1 - \tau,$$

$\Rightarrow \tau =$ index of progressivity

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Data and income definitions

- PSID, 1969-2016 waves
- Information on taxes from the PSID until 1991; NBER's TAXSIM after then
- Pre-tax
  = labor income + asset part of income from farm, business, roomers + rent received + interest and dividend income + transfer income

  transfer income
  = ADC/AFDC + Social Security benefits + income from retirement pay, pension or annuities + unemployment and workmen's compensation + alimony and child support received + help from relatives + other welfare + SSI + income from other sources
- Post-tax= pre-tax - federal taxes paid

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Sample selection

(a) Sample Selection for RDU

Sample	Selected out	Selected in
Initial sample		161,321
Positive income	1,092	160,229
1969-2016	5,560	154,669
After income trimming	2,248	152,421
Has all values of income	1,914	150,507
Has consistent income	6	150,501
$\lvert\text{DFBETA}\rvert < 1$	1	150,500

(b) Sample Selection by household type

Sample	Selected out	Selected in
Initial sample		161,321
Positive income	1,092	160,229
1969-2016	5,560	154,669
After income trimming	2,204	152,465
Has all values of income	1,870	150,595
Has consistent income	5	150,590
	Singles	
$\lvert\text{DFBETA}\rvert < 1$	1	50,561
	Married Couples	
$\lvert\text{DFBETA}\rvert < 1$	0	93,166
	Cohabiters	
$\lvert\text{DFBETA}\rvert < 1$	17	6,845

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Estimation strategy

- OLS regression

$$\log(\text{post-tax income})_{i,t} = \alpha_t + \beta_t \log(\text{pre-tax income})_{i,t} + \varepsilon_{i,t},$$

using income for household i in year t

- Obtain tax parameters as

$$\hat{\lambda}_t = 1 - \exp(\hat{\alpha}_t),$$
$$\hat{\tau}_t = 1 - \hat{\beta}_t,$$

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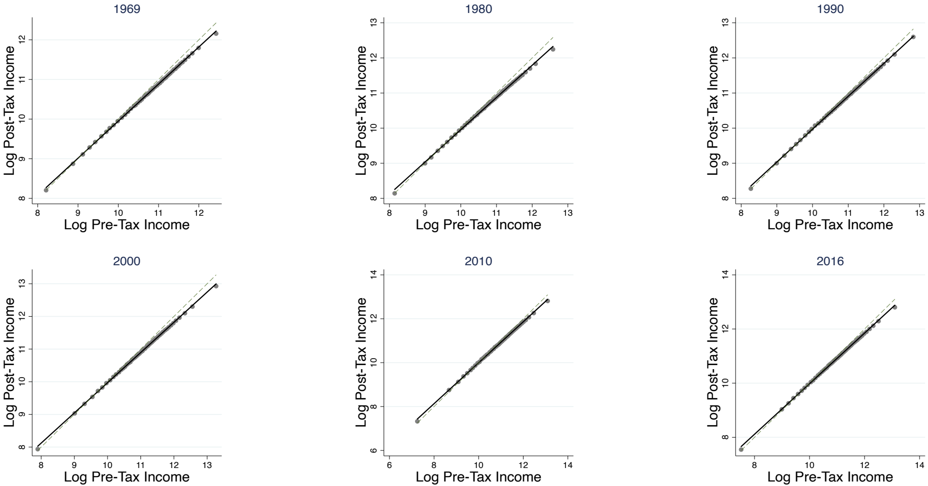
Fit of the tax function



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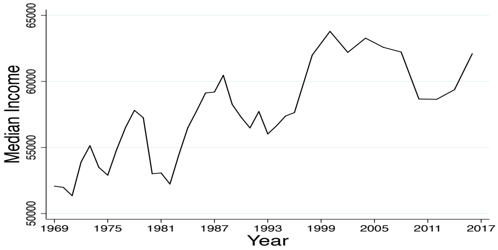
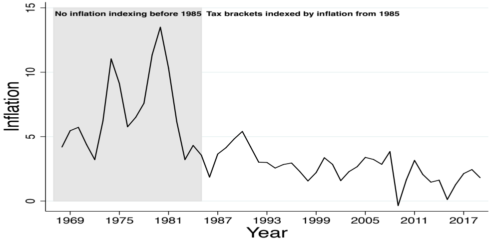
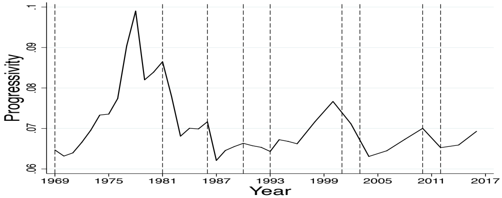
More graphs for the RDU







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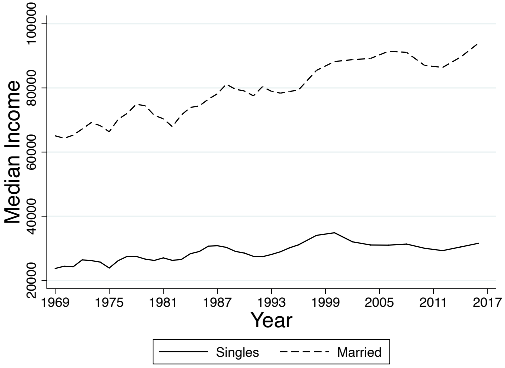
More Graphs for Couples and Singles



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Wages

- i = gender, j = marital status, t = age (time)
- Wages are functions of
  - Human capital, $\bar{y}_t^i$, measured as average past earnings
  - Wage shocks, ϵ_t^i, which follow an AR(1) that depends on gender

$$\ln \epsilon_{t+1}^i = \rho_\varepsilon^i \ln \epsilon_t^i + \upsilon_t^i, \;\; \upsilon_t^i \sim N(0, (\sigma_\upsilon^i)^2)$$

- Wages: $e_t^i(\bar{y}_t^i)\epsilon_t^i$

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Marriage and Divorce

- Marriage
  - Probability of marrying: function of age, gender, and wage shock $\nu_{t+1}(i, \epsilon_t^i)$
  - Assortative mating in productivity: probability of meeting with a partner with a certain wage shock depends on your wage shock $\xi_{t+1}(\cdot) = \xi_{t+1}(\epsilon_{t+1}^p | \epsilon_{t+1}^i, i)$
  - Conditional partner's productivity, distribution of partner's characteristics are assets and human capital: $\theta_{t+1}(a_{t+1}^p, \bar{y}_{t+1}^p | \epsilon_{t+1}^p)$
- Divorce probability: function of age and wage shocks of both spouses $\zeta_t(\epsilon_t^1, \epsilon_t^2)$

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Children

- Exogenous fertility
  - Number and age structure of children depends on maternal age and marital status: $f^{0,5}(i,j,t), f^{6,11}(i,j,t)$
- Time costs of raising children
- Monetary costs of raising children
  - Consumption cost: $\eta_t^{i,j}$
  - Childcare cost per child: $\tau_c^{0,5}, \tau_c^{6,11}$

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Health Risks (after age 66)

- Age, gender, marital status, and current health ψ_t^i affect evolution of
  - Health $\pi_t^{i,j}(\psi_t^i)$
  - Medical expenses $m_t^{i,j}(\psi_t^i)$
  - Survival $s_t^{i,j}(\psi_t^i)$

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Early Retirement Stage, Singles

- Single individuals don't get married anymore
- No dependent children
- Decide whether to retire or not

$$V^s(t, i, a_t^i, \epsilon_t^i, \bar{y}_t^i) = \max_{D_t^i} \Big((1 - D_t^i) N^s(t, i, a_t^i, \epsilon_t^i, \bar{y}_t^i) + D_t^i S^s(t, i, a_t^i, \bar{y}_t^i, t) \Big),$$

- If retired, no longer able to work

Early Retirement Stage, Singles who Decided not to Claim SS

$$N^s(t, i, a_t^i, \epsilon_t^i, \bar{y}_t^i) = \max_{c_t, a_{t+1}^i, n_t^i} \left(v^i(c_t, l_t^{i,j}, \eta_t^{i,1}) + \beta E_t V^s(t+1, i, a_{t+1}^i, \epsilon_{t+1}^i, \bar{y}_{t+1}^i) \right),$$

$$Y_t^i = e_t^i(\bar{y}_t^i)\epsilon_t^i n_t^i,$$

$$T(\cdot) = T(Y_t^i + r a_t^i, i, j, t),$$

$$\bar{y}_{t+1}^i = (\bar{y}_t^i(t - t_0) + (\min(Y_t^i, \widetilde{y}_t)))/(t + 1 - t_0),$$

$$c_t + a_{t+1}^i = (1 + r)a_t^i + Y_t^i - \tau_t^{SS} \min(Y_t^i, \widetilde{y}_t) - T(\cdot),$$

$$a_{t+1}^i \geq 0,$$

Early Retirement Stage, Singles who Have Claimed SS ($j = 1$)

- $\bar{y}_r^i$: Annual accumulated social security earnings (PI)
- tr: Retirement age

$$S^s(t, i, a_t^i, \bar{y}_r^i, tr) = \max_{c_t, a_{t+1}^i} \left(v^i(c_t, L^{i,j}, \eta_t^{i,1}) + \beta E_t S^s(t+1, i, a_{t+1}^i, \bar{y}_r^i, tr) \right),$$

$$Y_t^i = SS(\bar{y}_r^i, tr),$$

$$T(\cdot) = T(Y_t^i + ra_t^i, i, j, t),$$

$$c_t + a_{t+1}^i = (1+r)a_t^i + Y_t^i - T(\cdot),$$

$$a_{t+1}^i \geq 0,$$

Working period

Recursive Problem for Retired Singles ($j = 1$)

- ψ_t^i : Health status (good or bad)

$$R^s(t,i,a_t^i,\psi_t^i,\bar{y}_r^i,tr) = \max_{c_t,a_{t+1}^i}\left(v^i(c_t,L^{i,j},\eta_t^{i,1}) + \beta s_t^{i,j}(\psi_t^i)E_t R^s(t+1,i,a_{t+1}^i,\psi_{t+1}^i,\bar{y}_r^i,tr)\right),$$

$$Y_t^i = SS(\bar{y}_r^i, tr),$$

$$T(\cdot) = \tau\left(Y_t^i + ra_t^i, i, j, t\right),$$

$$B(a_t^i, Y_t^i, \psi_t^i, \underline{c}(j)) = \max\left\{0, \underline{c}(j) - \left\{(1+r)a_t^i + Y_t^i - m_t^{i,j}(\psi_t^i) - T(\cdot)\right\}\right\},$$

$$c_t + a_{t+1}^i = (1+r)a_t^i + Y_t^i + B(a_t^i, Y_t^i, \psi_t^i, \underline{c}(j)) - m_t^{i,j}(\psi_t^i) - T(\cdot),$$

$$a_{t+1}^i \geq 0,$$

Working period

Early Retirement stage, Couples

- Couples don't get divorced anymore
- Decide whether to retire or not at the same time
- If retired, no longer able to work

$$V^c(t, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = \max_{D_t}\Big((1 - D_t)N^c(t, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) + D_t S^c(t, a_t, \bar{y}_t^1, \bar{y}_t^2, t)\Big),$$

Early retirement, do not retire Early retirement, retire

Early Retirement Stage, Couples who Decided not to Claim SS ($j = 2$)

$$N^c(t, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = \max_{c_t, a_{t+1}, n_t^1, n_t^2} \Bigg(w(c_t, l_t^{1,j}, l_t^{2,j}, \eta_t^{i,j})$$

$$+ \beta E_t V^c(t+1, a_{t+1}, \epsilon_{t+1}^1, \epsilon_{t+1}^2, \bar{y}_{t+1}^1, \bar{y}_{t+1}^2) \Bigg),$$

$$l_t^{i,j} = L^{i,j} - n_t^i - \Phi_t^{i,j} I_{n_t^i},$$

$$Y_t^i = e_t^i(\bar{y}_t^i)\epsilon_t^i n_t^i,$$

$$T(\cdot) = T(ra_t + Y_t^1 + Y_t^2, i, j, t),$$

$$c_t + a_{t+1} = (1+r)a_t + Y_t^1 + Y_t^2 - \tau_t^{SS}(\min(Y_t^1, \widetilde{y}_t) + \min(Y_t^2, \widetilde{y}_t)) - T(\cdot),$$

$$\bar{y}_{t+1}^i = (\bar{y}_t^i(t - t_0) + (\min(Y_t^i, \widetilde{y}_t)))/(t + 1 - t_0),$$

$$a_{t+1} \geq 0, \quad n_t^1, n_t^2 \geq 0,$$

▸ Working stage

Early Retirement Stage, Couples who Decided to Claim SS ($j = 2$)

$$S^c(t, a_t, \bar{y}_r^1, \bar{y}_r^2, tr) = \max_{c_t, a_{t+1}} \left(w(c_t, L^{1,j}, L^{2,j}, \eta_t^{i,j}) + \beta E_t S^c(t+1, a_{t+1}, \bar{y}_r^1, \bar{y}_r^2, tr) \right),$$

SS income

$$Y_t^i = \max\left\{ SS(\bar{y}_r^i, tr), \frac{1}{2} SS(\bar{y}_r^P, tr) \right\}, \quad i = 1, 2 \quad (1)$$

$$Y_t = Y_t^1 + Y_t^2, \quad (2)$$

Tax

$$T(\cdot) = T(ra_t + Y_t, i, j, t), \quad (3)$$

$$c_t + a_{t+1} = (1+r)a_t + Y_t - T(\cdot),$$

$$a_{t+1} \geq 0,$$

Working stage

Recursive Problem for Retired Couples ($j = 2$)

$$
\begin{aligned}
R^c(t, a_t, \psi_t^1, \psi_t^2, \bar{y}_r^1, \bar{y}_r^2, tr) = \max_{c_t, a_{t+1}} \Big(& w(c_t, L^{1,j}, L^{2,j}, \eta_t^{i,j}) + \\
& \beta s_t^{1,j}(\psi_t^1) s_t^{2,j}(\psi_t^2) E_t R^c(t+1, a_{t+1}, \psi_{t+1}^1, \psi_{t+1}^2, \bar{y}_r^1, \bar{y}_r^2, tr) + \\
& \beta s_t^{1,j}(\psi_t^1)(1 - s_t^{2,j}(\psi_t^2)) E_t R^s(t+1, 1, a_{t+1}, \psi_{t+1}^1, \bar{\bar{y}}_r^1, tr) + \\
& \beta s_t^{2,j}(\psi_t^2)(1 - s_t^{1,j}(\psi_t^1)) E_t R^s(t+1, 2, a_{t+1}, \psi_{t+1}^2, \bar{\bar{y}}_r^2, tr) \Big)
\end{aligned}
$$

- t : Age
- a_t : Net worth from previous period
- ψ_t^i : Health status (good or bad) for each spouse
- $\bar{y}_r^1$: Annual accumulated social security earnings for men
- $\bar{y}_r^2$: Annual accumulated social security earnings women
- tr: Retirement age

Recursive Problem for Retired Couples ($j = 2$)

Survival $$\bar{\bar{y}}_r^i = \max(\bar{y}_r^1, \bar{y}_r^2) \qquad i = 1, 2$$

SS income $$Y_t^i = \max\left\{SS(\bar{y}_r^i, tr), \frac{1}{2}SS(\bar{y}_r^P, tr)\right\} \qquad i = 1, 2$$

$$Y_t = Y_t^1 + Y_t^2$$

Tax $$T(\cdot) = T(ra_t + Y_t, i, j, t)$$

Budget $$c_t + a_{t+1} = (1+r)a_t + Y_t + B(\cdot) - m_t^{1,j}(\psi_t^1) - m_t^{2,j}(\psi_t^2) - T(\cdot)$$

Transfer $$B(a_t, Y_t, \psi_t^1, \psi_t^2, \underline{c}(j)) = \max\Big\{0, \underline{c}(j) - \Big[(1+r)a_t + Y_t - m_t^{1,j}(\psi_t^1) - m_t^{2,j}(\psi_t^2) - T(\cdot)\Big]\Big\}$$

$$a_{t+1} \geq 0$$

Individual's Discounted Present Value of Being in a Marriage ($j = 2$)

Evaluated under optimal policies

$$\hat{W}^c(t, i, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = v^i(\hat{c}_t(\cdot), \hat{l}_t^{i,j}, \eta_t^{i,j}) + \beta(1-\zeta(\cdot))E_t\hat{W}^c(t+1, i, \hat{a}_{t+1}(\cdot), \epsilon_{t+1}^1, \epsilon_{t+1}^2, \bar{y}_{t+1}^1, \bar{y}_{t+1}^2) + \beta\zeta(\cdot)E_t W^s(t+1, i, \hat{a}_{t+1}(\cdot)/2, \epsilon_{t+1}^i, \bar{y}_{t+1}^i)$$

$$\hat{R}^c(t, i, a_t, \psi_t^1, \psi_t^2, \bar{y}_r^1, \bar{y}_r^2) = v^i(\hat{c}_t(\cdot), L^{i,j}, \eta_t^{i,j}) + \beta s_t^{i,j}(\psi_t^i) s_t^{p,j}(\psi_t^p) E_t\hat{R}^c(t+1, i, \hat{a}_{t+1}(\cdot), \psi_{t+1}^1, \psi_{t+1}^2, \bar{y}_r^1, \bar{y}_r^2) + \beta s_t^{i,j}(\psi_t^i)(1 - s_t^{p,j}(\psi_t^p)) E_t R^s(t+1, i, \hat{a}_{t+1}(\cdot), \psi_{t+1}^i, \bar{\bar{y}}_r^i)$$

▸ Working period

Individual's Discounted Present Value of Being in a Marriage ($j = 2$)

Evaluated under optimal policies

$$\hat{N}^c(t, i, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = v^i(\hat{c}_t(\cdot), \hat{l}_t^{i,j}, \eta_t^{i,j}) + \beta E_t \hat{V}^c(t+1, i, \hat{a}_{t+1}(\cdot), \epsilon_{t+1}^1, \epsilon_{t+1}^2, \bar{y}_{t+1}^1, \bar{y}_{t+1}^2)$$

$$\hat{S}^c(t, i, a_t, \bar{y}_r^1, \bar{y}_r^2, tr) = v^i(\hat{c}_t(\cdot), L^{i,j}, \eta_t^{i,j}) + \beta E_t S^c(t+1, i, \hat{a}_{t+1}(\cdot), \bar{y}_r^1, \bar{y}_r^2, tr)$$

$$\hat{V}^c(t, i, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) = (1 - \hat{D}_t(\cdot))\hat{N}^c(t, i, a_t, \epsilon_t^1, \epsilon_t^2, \bar{y}_t^1, \bar{y}_t^2) + \hat{D}_t(\cdot)\hat{S}^c(t, i, a_t, \bar{y}_r^1, \bar{y}_r^2, t)$$

▸ Working period

Two-Step Estimation Strategy

- First step inputs
  - Fix some parameters to calibrated or estimated values (externally to model)
  - Estimate from data directly (taxes, demographics, wage risk, health risk, human capital accumulation function...)
- Second step
  - Estimate other parameters matching data targets

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Model Estimates

- Model fits well profiles of
  - Participation of single and married men and women by age
  - Hours worked by workers for single and married men and women by age
  - Savings of single and married couples by age
- Married women work much less than married men due to
  - Lower wages (lower initial human capital, lower wage net of childcare costs)
  - Less available time due to home production
  - Marriage-related policies
- Model also implies empirically plausible elasticities of labor supply (intensive and extensive) for single and married men and women by age

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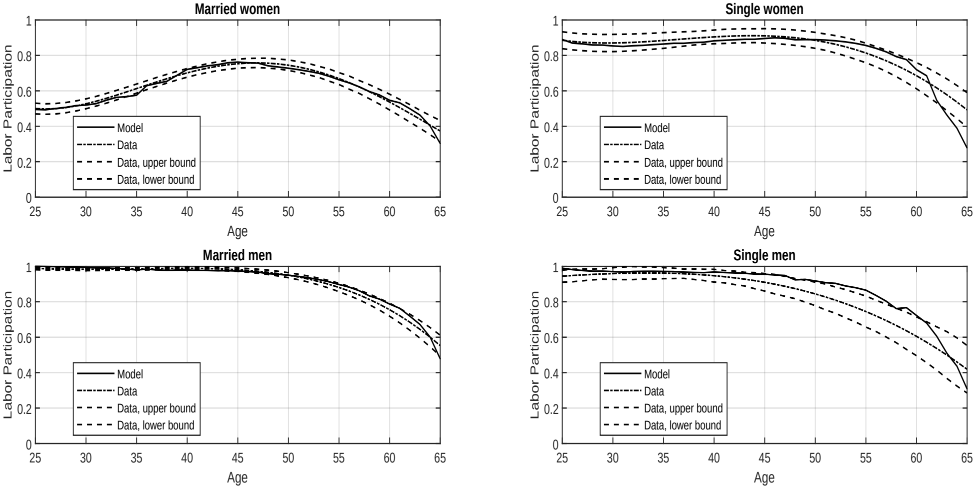
Model Fit: Participation



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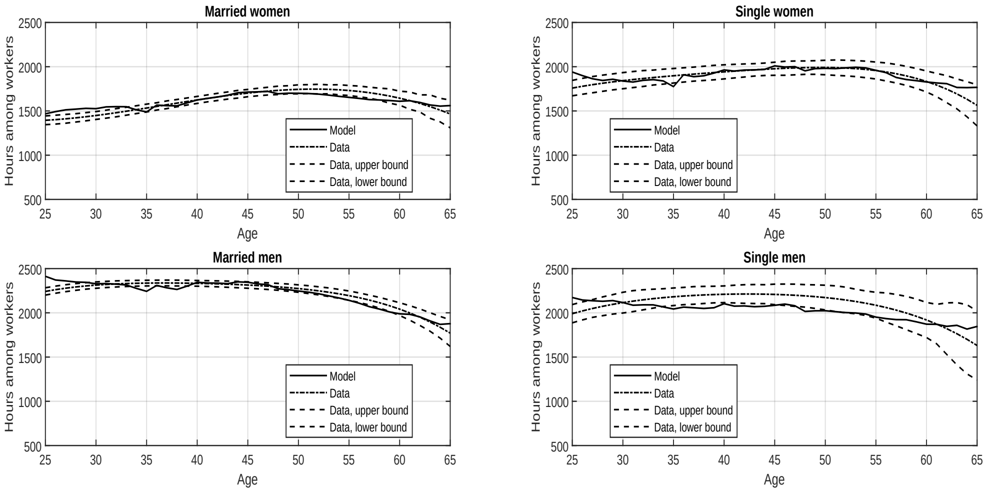
Model Fit: Hours



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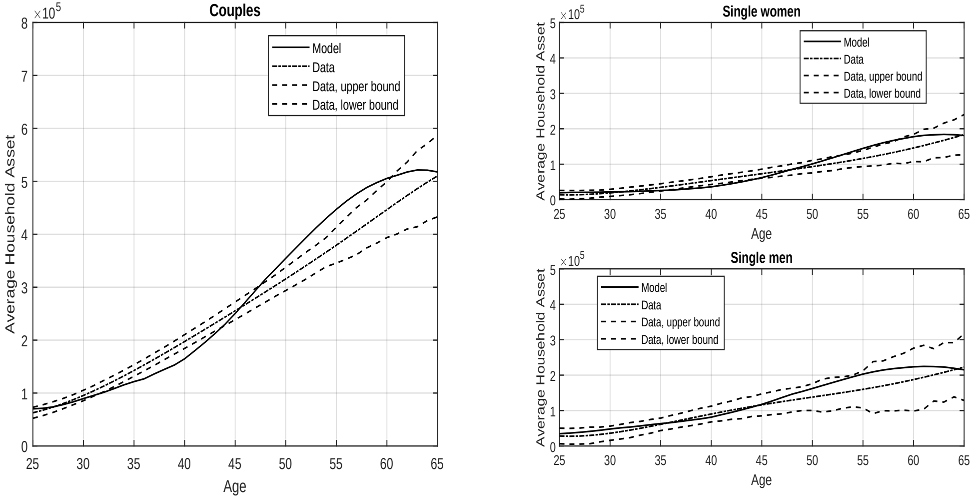
Model Fit: Wealth



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Labor Supply Elasticity, Temporary Wage Change

	Participation				Hours among workers			
	Married		Single		Married		Single	
	W	M	W	M	W	M	W	M
30	1.0	0.0	0.6	0.2	0.3	0.3	0.6	0.4
40	0.7	0.1	0.4	0.2	0.4	0.5	0.8	0.5
50	0.7	0.2	0.4	0.8	0.4	0.5	0.7	0.4
60	1.2	0.7	2.0	1.7	0.3	0.3	0.5	0.6

Table: Labor supply elasticity, temporary wage change, 1945 cohort. W: women, M: men.

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