Housing Tax Reform

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Motivation

Housing is largest component of household consumption and wealth

Housing tax policy targets consumption and liquidity of housing

- consumption tax: property tax, mortgage interest deduction, ...
- transaction tax: capital gains tax, stamp duty

Question: How to efficiently design and reform housing tax policy?

What I do

Use an incomplete markets life cycle economy with housing

1. housing input in home production
2. illiquid due to adjustment costs
3. private, stochastic skill risk; elastic labor supply

1. Measure current tax policy using tax records for the Netherlands
2. Study dynamic Mirrlees theory for efficient housing tax reform
3. Quantify theory for economy matched to the Netherlands

What I find

1. Measures of current housing consumption and transaction tax
   - average owner's consumption *subsidy* of 8% (range from 20% to −5%)
   - transaction tax of 6%

2. Theoretical motives to deviate from uniform commodity taxation
   - tax housing when house complements leisure in home production
   - subsidize and tax transactions to insure against adjustment costs

3. Housing consumption tax should be similar to tax on other goods

   house is weak complement to leisure → housing consumption *tax* of 14%

Model

Standard life cycle model

Three key ingredients:

- home production preferences $u(c, d, \ell) = v(c) + \overbrace{g(d, \ell)}^{\text{home technology}}$
- idiosyncratic skill shocks θ^t, labor supply $y = \theta(1 - \ell)$
- own or rent decision driven by
  - tax treatment of owning versus renting
  - size restrictions: own if $d \geq \underline{d} \equiv \chi \underline{h}$ and rent if $d \leq \underline{d}$
  - adjustment costs

Plan for today

Study optimality condition for housing services in two problems

1. Positive economy of the Netherlands
    - measure current effective tax policy
2. Mirrlees problem
    - characterize and quantify efficient tax policy

Owner constraints

- savings in financial assets, house, mortgage, $s = a + p_H h - m \geq 0$

- loan-to-value and income restrictions, $m \leq \kappa_t(h, y)$

- budget constraint

$$(1+\tau_c)c + \Psi(d, d_-) + s' = y - T_t^y(\tilde{y}) + Ra - T^a(a) + \left(p_H{}' - \tau_p p_H - \delta\right)h - Rm$$

where,

- adjustment costs: $\Psi\left(d, d_-\right) = \overbrace{\Phi\left(d, d_-\right)}^{\text{technology}} + \overbrace{T^t(d, d_-)}^{\text{transaction tax}}$

- taxable income: $\tilde{y} = y - rm + \tau_o p_H h$

Taxes

- Household optimality condition:

$$\frac{u_{d,t}}{u_{c,t}} = p \; \frac{1 + \overbrace{\tau_{di}}^{\text{consumption tax}}}{1 + \tau_c}$$

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$$\frac{u_{d,t}}{u_{c,t}} = p \, \frac{1 + \overbrace{\tau_{di}}^{\text{consumption tax}}}{1 + \tau_c} + \Phi_{1,t} + \frac{\overbrace{\tau_{ti}^{\text{buy}}}^{\text{buyer's tax}}}{1 + \tau_c}$$

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- Efficient optimality condition:

$$\frac{u_{d,t}}{u_{c,t}} = p \quad \ldots \quad + \Phi_{1,t} + \quad \ldots \quad + \beta \mathbb{E}_t \left(\Phi_{2,t+1} + \quad \ldots \quad \right) \frac{u_{c,t+1}}{u_{c,t}}$$

Taxes

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1. Measure current tax policy using tax records for the Netherlands
2. Study theory for efficient consumption and transaction tax
3. Quantify efficient consumption and transaction tax

Current Housing Tax Policy

- Administrative micro data from 2006 to 2014 on:
    - tax assessed property values
    - mortgage balance
    - who lives where
    - hours and earnings
    - marginal tax rates

- National accounts data on:
    - consumption shares

Used to measure current policy, calibrate wage process, preferences

Measures of housing consumption and transaction tax

1. Effective tax rate on housing consumption for household i

$$\tau_{di} \equiv \left(\frac{\text{user cost under current policy}}{\text{user cost absent taxation}}\right)_i - 1$$

2. Effective tax rate on transactions

$$\tau_{ti}^{\text{buy}} \equiv T_1^t(d_i, d_-) \qquad \text{for house you buy}$$

$$\tau_{ti}^{\text{sell}} \equiv T_2^t(d_i, d_-) \qquad \text{for house you sell}$$

Later compare to efficient consumption and transaction tax rate

Transaction tax

- Statutory tax rate when buying

  $\tau_{ti}^{\text{buy}} = 6\%$

- Statutory tax rate when selling

  $\tau_{ti}^{\text{sell}} = 0\%$

User cost absent taxation

$r \; + \; \hat{\delta} \; - \; \pi^H$

- opportunity cost of capital, $r = 3.1\%$

  average interest rate on mortgages

- depreciation rate of housing, $\hat{\delta} = 2.4\%$

  depreciation of housing stock, capital accounts

- capital gain, $\pi^H = -2.8\%$

  nominal house price inflation -0.7%, price inflation 2.1%

$\Longrightarrow$ 8.3%, or monthly rental value of 1,725 for 250K property

User cost for homeowner i

$$\underbrace{r + \hat{\delta} - \pi^H}_{\text{baseline, uc}_n} + \overbrace{\tau_p}^{\text{property tax}} - \underbrace{\tau_{yi} r \lambda_i}_{\text{mortgage interest deduction}} - \overbrace{\tau_{ai}(1 - \lambda_i)}^{\text{exclusion from asset income tax}} + \underbrace{\tau_{yi}\tau_o}_{\text{imputed rent tax}}$$

with $\tau_p = 0.1\%$, $\tau_o = 0.6\%$, and loan-to-value ratio $\lambda_i \equiv m_i / p_H h_i$

Use administrative data to measure:

1. property values
2. mortgage balances
3. marginal tax rates

User cost for homeowner i

$$\underbrace{r + \hat{\delta} - \pi^H}_{\text{baseline, uc}_n} + \overbrace{\tau_p}^{\text{property tax}} - \underbrace{\tau_{yi} r \lambda_i}_{\text{mortgage interest deduction}} - \overbrace{\tau_{ai}(1-\lambda_i)}^{\text{exclusion from asset income tax}} + \underbrace{\tau_{yi}\tau_o}_{\text{imputed rent tax}}$$

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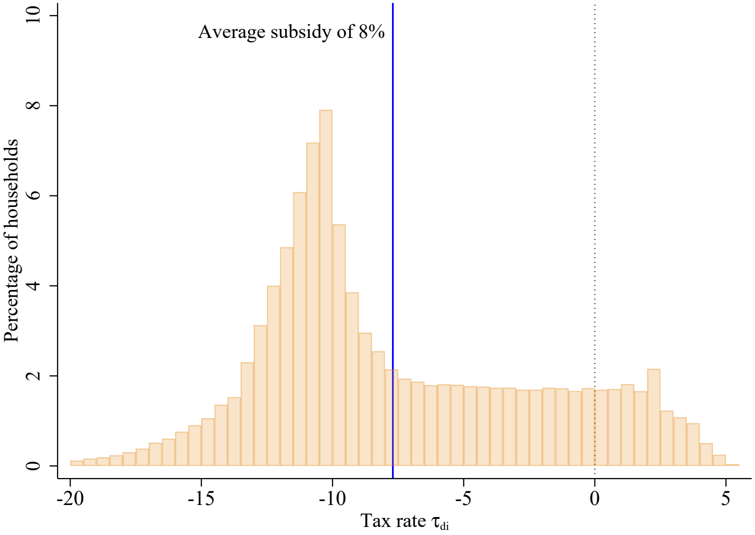
Use administrative data to measure:

1. property values
2. mortgage balances
3. marginal tax rates

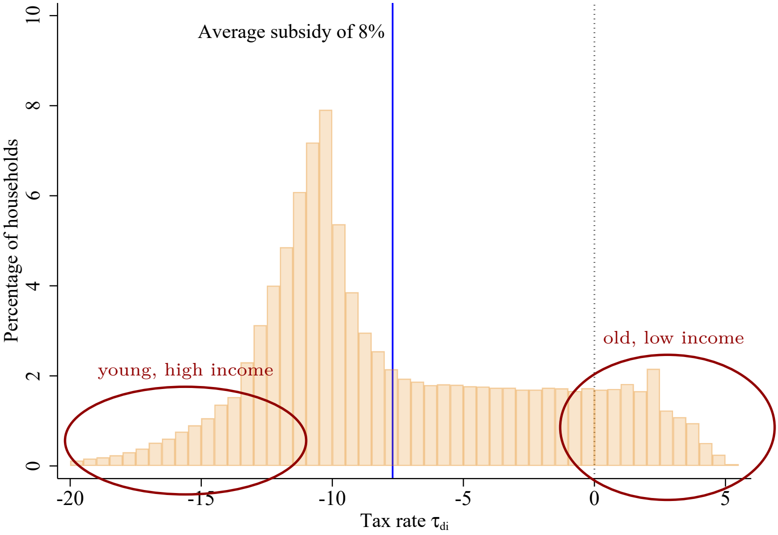
Then, construct $\tau_{di} \equiv \left(\frac{\text{user cost under current policy}}{\text{user cost absent taxation}}\right)_i - 1$

Histogram of owner's housing consumption tax

By age



Histogram of owner's housing consumption tax



Recap measurement

- Transaction tax rate on buyers 6%; on sellers 0%
- Average housing consumption subsidy of 8% (from 20% to −5%)

The model optimality condition for housing services:

$$\frac{u_{d,t}}{u_{c,t}} = p \underbrace{\frac{1+\overbrace{\tau_{di}}^{\text{consumption tax}}}{1+\tau_c}}_{\left[\frac{0.80}{1.13}, \frac{1.05}{1.13}\right]} + \Phi_{1,t} + \underbrace{\frac{\overbrace{\tau_{ti}^{\text{buy}}}^{\text{buyer's tax}}}{1+\tau_c}}_{\frac{0.06}{1.13}} + \beta \mathbb{E}_t \left[\left(\Phi_{2,t+1} + \underbrace{\frac{\overbrace{\tau_{ti}^{\text{sell}}}^{\text{seller's tax}}}{1+\tau_c}}_{0} \right) \frac{u_{c,t+1}}{u_{c,t}} \right]$$

Is this efficient? How to efficiently reform housing tax policy?

Reform Theory

Efficient reform

So far, positive economy

- measurement of effective housing tax policy
- values under current policy for every household

Next, analyze efficient policy reform

- characterize efficient allocations and housing tax policy
- Pareto improvements using values under current policy

Efficiency

- allocation for household $i \equiv (\underbrace{j, \theta^{t-1}})$ is $x(i) \equiv \{x_{j+v}(\theta^{t+v})\}_{v=0}^{T-t}$

  birth year, private skill history

  $x \equiv (c, d, y)$

- set of households: all current $(0, \theta^{t-1})$ and future cohorts (j, θ_0)

- an allocation is feasible iff it is resource and incentive feasible

- allocation x is efficient iff there does not exist a feasible allocation $\hat{x}$ where all households are better off with some strictly better off

Efficient reform in practice

- Formulate planning problem to characterize efficient allocations
- Exploit separability to solve household by household
- Solve component problem using a direct mechanism
  - Include only local downward incentive constraints
- Characterize efficient allocation, map to tax wedges

Housing wedge definitions

Given a history θ^{t-1}

1. Consumption wedge

$$\frac{u_d}{u_c} \equiv p(1+\tau_d(\theta)) + \Phi_1 + \overbrace{\frac{1}{R}\sum \pi\left(\theta'|\theta\right)\Phi_2\left(d(\theta'), d\right)}^{\text{risk-neutral pricing}}$$

2. Transaction wedges

$$\frac{u_d}{u_c} = p(1+\tau_d(\theta)) + \Phi_1 + \underbrace{\beta\sum \pi\left(\theta'|\theta\right)\frac{u_c(\theta')}{u_c}\left(\Phi_2\left(d(\theta'), d\right)\right.}_{\text{risk-averse pricing}} \left. + \tau_t(\theta')\right)$$

Characterize, then compare to current housing tax policy

Housing consumption wedge

Detail House price

- $\tau_d(\theta) \geq 0$ iff housing and leisure are complements $g_{d\ell}(d, \ell) > 0$
- Prevent high type from mimicking low type
  - benefit of deviation is additional home production
  - depress housing to discourage deviation if complements
- Relax incentive constraint
  - provide additional insurance

Housing transaction wedge

- tax transactions when households sell their house in good states

  $u_c(c_-) \geq \beta R u_c(c(\theta))$

- precautionary downsizing due to adjustment cost in bad states
  - larger house increases exposure to future adjustment cost
  - with incomplete markets, households downsize to reduce exposure

- transaction tax insures households against adjustment costs
  - tax transactions in good times, subsidize transactions in bad times

$$\tau_t(\theta) = \Phi_2\big(d(\theta), d_-\big)\left(\underbrace{\frac{1}{\beta R}\frac{u_c}{u_c(\theta)}}_{\text{premium}} - \underbrace{1}_{\text{payout}}\right)$$

Efficient versus current policy

- From the planning problem

$$\frac{u_{d,t}}{u_{c,t}} = p \underbrace{\left(1 + \tau_d(\theta)\right)}_{\geq 1 \text{ iff } g_{d\ell} \geq 0} + \Phi_{1,t} + \quad 0 \quad + \beta \mathbb{E}_t \left(\Phi_{2,t+1} + \underbrace{\tau_t(\theta')}_{\lesseqgtr 0} \right) \frac{u_{c,t+1}}{u_{c,t}}$$

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- From the model of the Netherlands

$$\frac{u_{d,t}}{u_{c,t}} = p \underbrace{\frac{1+\tau_{di}}{1+\tau_c}}_{\left[\frac{0.80}{1.13}, \frac{1.05}{1.13}\right]} + \Phi_{1,t} + \underbrace{\frac{\tau_{ti}^{\text{buy}}}{1+\tau_c}}_{\frac{0.06}{1.13}} + \beta \mathbb{E}_t \left(\Phi_{2,t+1} + \underbrace{\frac{\tau_{ti}^{\text{sell}}}{1+\tau_c}}_{0} \right) \frac{u_{c,t+1}}{u_{c,t}}$$

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Takeaways:

1. current consumption subsidy can be efficient only if substitutes
2. current transaction tax is not efficient

Recap theory

Measurement

- transaction tax rate on buyers 6%; on sellers 0%
- average consumption subsidy of 8% (20% subsidy to 5% tax)

Theory

- subsidize and tax transactions to insure against adjustment costs
- tax housing when house complements leisure in home production

Quantify complementarity housing and leisure in home production

Quantitative Reform

Calibrate positive economy

1. Estimate skill process
2. Parameterize government policy
3. Parameterize technology
4. Calibrate preferences

- Do 1, 2, and 3 outside the model
- Use positive economy for 4

Overview

Households

- $u(c, d, \ell) = \gamma \log c + (1-\gamma) \log \left(\left(\omega d^{\frac{\sigma-1}{\sigma}} + (1-\omega)\,\ell^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \right)$

  housing services d and leisure ℓ complement iff $\sigma \leq 1$

- six types based on education level, differ in AR(1) skill process

Government

- collects taxes, provides pension benefits, regulates mortgages

Technology Φ

- 2% buyer's fee; 1.5% seller's fee

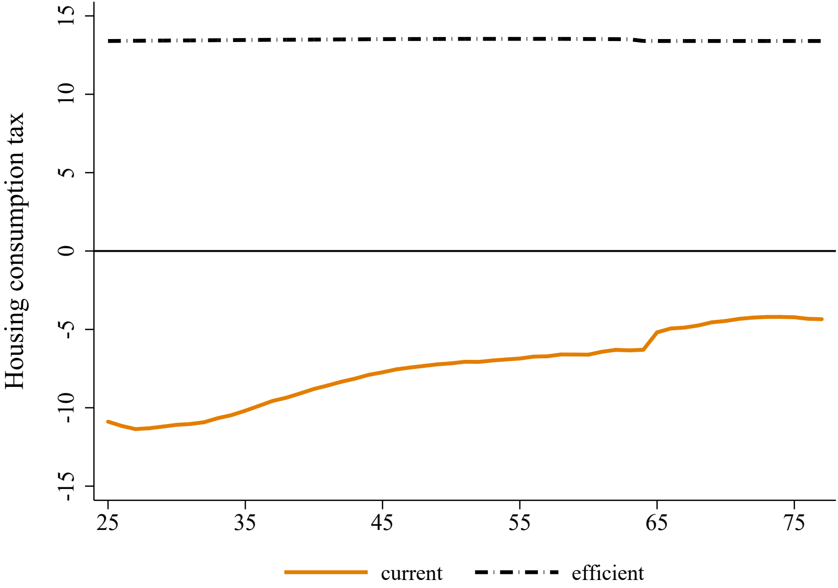
Today, transaction costs are inefficient in planner problem, $\Phi = 0$

	Value	Target	Data	Model
γ	0.343	Consumption to output ratio	0.64	0.66
ω	0.144	Housing share in consumption	0.17	0.16
σ	0.951	Covariance input and price ratio, $\hat{\beta}$	-0.43	-0.43

Identify elasticity σ by indirect inference from regression coefficient

$$\log\left(\frac{\ell}{d}\right)_i = \mathbb{C} + \beta \log\left(\frac{w}{p}\right)_i + \varepsilon_i$$

Current policy is not efficient



Simple Pareto improving reform

Use efficient reform to guide simple steady state policy reform

holding government debt position constant by adjusting transfers

$$\tau_{di} \propto \overbrace{\tau_p \; - \; \tau_{yi} r \lambda_i \; - \; \tau_{ai}(1-\lambda_i) \; + \; \tau_{yi}\tau_o}^{\text{increase to 14\%}}$$

- increase τ_p from 0.1% to 1.2% to move from −8% to 14%
- lower τ_o from 0.6% to 0.0% to ensure gain for high income groups

Δc	Δf_h	Welfare Gain by Education Group					
0.68	0.00	1.01	0.68	0.35	0.60	0.25	0.03

Conclusion

Conclusion

How to efficiently design and reform housing policy?

Theory

- tax housing services when housing services complement leisure
- tax and subsidize transactions to insure against adjustment costs

Quantitative

- effective housing *subsidy* of 8% for average owner decreases in age
- efficient housing *tax* of 14% almost constant over the life-cycle

Appendix

Related literature

- housing (over the life cycle, user cost)

  Laidler (1969); Aaron (1970); Poterba (1984); Gervais (2002); Fernández-Villaverde, Krueger (2010); Sommer, Sullivan (2018); Kaplan, Mitman, Violante (2019).

- home production

  Becker (1965); Gronau (1977); Greenwood, Hercowitz (1991); Benhabib, Rogerson, Wright (1991); Aguiar, Hurst (2005); Boerma, Karabarbounis (2019).

- public finance

  Mirrlees (1971); Atkinson, Stiglitz (1976); Golosov, Kocherlakota, Tsyvinski (2003); Farhi, Werning (2013); Golosov, Troshkin, Tsyvinski (2016); Hosseini, Shourideh (2019).

- this paper: efficient tax reform for incomplete markets life cycle economy with illiquid housing capital and home production

Home production preferences

- time and expenditures produce goods

$$u(c, d, n_H, \ell) = v(c) + h(d, n_H, \ell)$$

- time constraint $\ell + n_M + n_H = 1$; effective labor supply $y = \theta n_M$

- household indirect utility given an allocation (c, d, y) and skills θ

$$\vartheta(c, d, y; \theta) = \max_{n_H \in [0, 1-n_M)} u(c, d, n_H, \ell) = v(c) + \tilde{h}(d, y)$$

Firms' problem

Construction firm

- commits to build houses $Q_{j+1-\iota}$ for period $j+1-\iota$
- builds in period j, valued at p^H_{j+1}, using general good ($p^H_{j+1} = 1$)
- in first period, commits to deliver houses in period ι

  $p^H_j = 1$ for $j > \iota$

Rental firm

- $p_r = \frac{1}{\chi}\Big(r(1-\tau_f) + \tau_p + \delta - \pi^H\Big)p^H$

Rental firm

- receive rent p_j per unit of housing services
- borrow at rate r to buy housing capital at p_j^H per unit
- incur maintenance cost δ, pay property tax τ_p
- sell housing capital at price p_{j+1}^H at the end of the period
- receive a subsidy on interest payments τ_f

$$p_{r,j} = \frac{1}{\chi}\Big(r(1-\tau_f) + \tau_p + \hat{\delta} - \pi_{j+1}^H\Big)p_j^H$$

Technology

- housing services

$D_j = \chi H_j$ services flow D proportional to housing stock H

Technology

- housing services

  $$D_j = \chi H_j$$

- time to build $\iota \geq 1$

  $$H_{j+1} = Q_{j+1-\iota} + H_j$$ constructions Q planned in advance

Technology

- housing services

  $$D_j = \chi H_j$$

- time to build $\iota \geq 1$

  $$H_{j+1} = Q_{j+1-\iota} + H_j$$

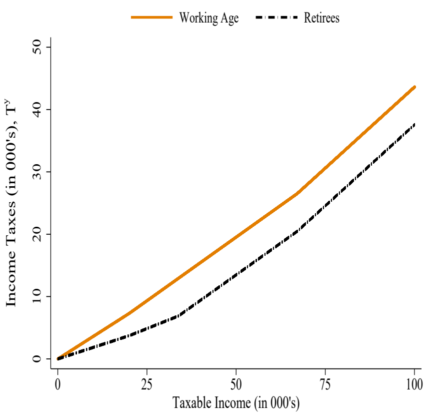
  housing supply perfectly inelastic in short run, perfectly elastic in long run

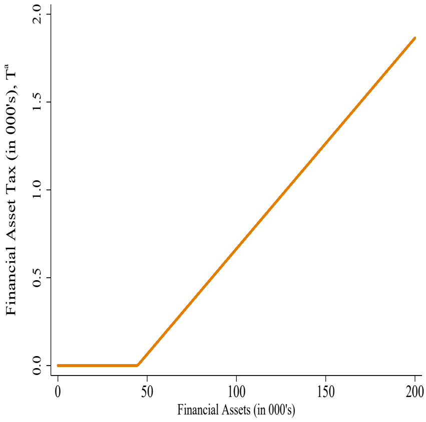
- general good

  $$C_j + I_j^K + I_j^H + G_j + \Phi_j + B_{j+1} = F\left(K_j, Y_j\right) + RB_j$$

  where $I_j^H = Q_{j+1-\iota} + \delta H_j$

Income and asset tax





Renter's constraints

- savings in financial assets, $s = a \geq 0$

- budget constraint

$$(1+\tau_c)c + p_r d + \Phi(d, d_-) + T^t(d, d_-) + s' = wy - T_t^y(\tilde{y}) + Ra - T^a(a)$$

  where,

  - rental price: p_r
  - taxable income: $\tilde{y} = wy$

- largest house to rent, $d \leq \chi \underline{h}$

Equilibrium

Given public spending, construction plans, initial private savings, aggregate assets, an equilibrium is an allocation and prices so that:

- allocation solves household problems
- prices are consistent with firm optimization
  factor prices, rental prices, house prices
- goods and housing market clear
- government budget constraint is satisfied

Homeowner as a firm

- taxable income $\tilde{y} = wy + \underbrace{\big(p_n - \overbrace{r\lambda_i}^{\text{mortgage interest deduction}} - r(1-\lambda_i) - \hat{\delta} - \pi^H\big)}_{\text{implies zero subsidy (=0)}} p^H h$

$$c + T^c(c) + \Psi(d, d_-) + s' = wy - T^y(\tilde{y}) + Ra + \big(p_H{}' - \delta\big)h - Rm$$

Home mortgage interest deduction is a subsidy because of a failure to tax housing consumption

Capital gains tax

- Accrual system

$$p_i = r + \hat{\delta} - (1 - \overbrace{\tau_\pi}^{\text{capital gains tax}})\pi^H + \tau_p - \tau_{yi} r \lambda_i - \tau_{ai}(1 - \lambda_i) + \tau_{yi}\tau_o$$

- Realization system

$$T^t(d_t, d_{t-1}) \quad \longrightarrow \quad T^t(d_t\,, d_{t-1}\,, p^H_{j+1}\,, \overbrace{p^H_a}^{\text{acquisition price}})$$

Measurement with complete asset markets

Back

Incomplete markets

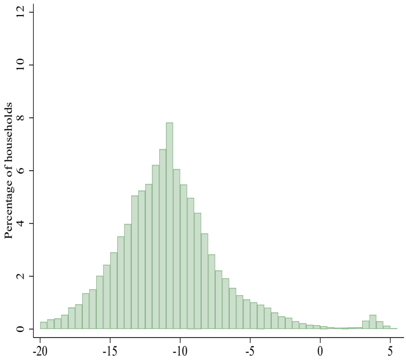
$$\frac{u_{d,t}}{u_{c,t}} = p \underbrace{\frac{1+\overbrace{\tau_{di}}^{\text{consumption tax}}}{1+\tau_c}}_{\left[\frac{0.80}{1.13},\frac{1.05}{1.13}\right]} + \Phi_{1,t} + \underbrace{\frac{\overbrace{\tau_{ti}^{\text{buy}}}^{\text{buyer's tax}}}{1+\tau_c}}_{\frac{0.06}{1.13}} + \beta\mathbb{E}_t\left[\left(\Phi_{2,t+1} + \underbrace{\frac{\overbrace{\tau_{ti}^{\text{sell}}}^{\text{seller's tax}}}{1+\tau_c}}_{0}\right)\frac{u_{c,t+1}}{u_{c,t}}\right]$$

Complete markets

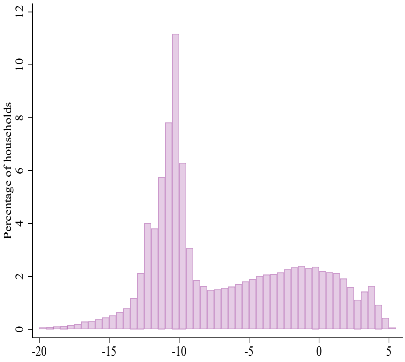
$$\frac{u_{d,t}}{u_{c,t}} = p\frac{1+\tau_{di}}{1+\tau_c} + \Phi_{1,t} + \frac{\tau_{ti}^{\text{buy}}}{1+\tau_c} + \frac{1}{R}\mathbb{E}_t\left[\Phi_{2,t+1} + \frac{\tau_{ti}^{\text{sell}}}{1+\tau_c}\right]$$

Housing consumption tax

Effective tax rate on housing consumption $\tau_{di} = p_i/p_n - 1$



(a) Ages 25−35



(b) Ages 50−65

User cost for renters i

Effective tax on housing consumption $\tau_{di} = p_r / p_n - 1 = -7.5\%$

$$p_r = \overbrace{r \ + \ \hat{\delta} \ - \ \pi^H}^{\text{baseline, } p^n} + \tau_p \ - \underbrace{\tau_f r}_{\text{financing subsidy}}$$

with property tax rate $\tau_p = 0.1\%$, and financing subsidy $\tau_f = 23.2\%$

Proof

Proposition. Allocation x with corresponding values $\mathcal{V}_j(x(i);\theta^{t-1})$ is efficient iff it solves the planner problem given $\mathcal{V}_j(x(i);\theta^{t-1})$ with a maximum of zero.

$\Rightarrow$ Suppose x does not solve the planner problem, let $\hat{x}$ be a solution. Since x is feasible, $\hat{x}$ generates excess resources. Construct $\tilde{x}$ identical to $\hat{x}$ but increase initial consumption (satisfying ICs). Allocation $\tilde{x}$ Pareto dominates x, which is a contradiction.

"resources are left on the table, hence households can be made better off"

$\Leftarrow$ Suppose x is not efficient, there exists a Pareto improving $\hat{x}$. Because $\hat{x}$ is feasible and yields $\mathcal{V}_j(x(j,\theta^{t-1});\theta^{t-1})$, $\hat{x}$ is a candidate solution to the planner problem. Construct $\tilde{x}$ equal to $\hat{x}$ but reduce initial consumption for i strictly better off under $\hat{x}$ (satisfying ICs). $\tilde{x}$ is feasible and increases excess resources, contradicting x solves the planner problem.

"Pareto improvement is feasible, hence there must be excess resources"

Proof by contradiction

$\Rightarrow$ Suppose $\hat{x}$, not x, solves the planner problem. Because x is feasible, $\hat{x}$ generates excess resources. Construct $\tilde{x}$ identical to $\hat{x}$ but increase initial consumption (satisfying IC).

$\Leftarrow$ Suppose $\hat{x}$ is a feasible Pareto improvement yielding values in excess of $\mathcal{V}_j(x(i); \theta^{t-1})$. Construct $\tilde{x}$ equal to $\hat{x}$ but reduce consumption for i strictly better off (satisfying IC).

Housing consumption tax

Back

$$\tau_d(\theta) = \Big(g_d\left(d(\theta), 1 - y(\theta)/\theta^+\right) - g_d\left(d(\theta), 1 - y(\theta)/\theta\right)\Big) \underbrace{q(\theta^+)}_{\text{value of relaxing IC}} / (p_j \pi(\theta))$$

- prevent high type from mimicking low type

  benefit of deviation is additional home production

  depress housing to discourage deviation when complements

- value of relaxing incentive constraint, $q(\theta^+)$

$$q(\theta^+) = I(\theta) + \beta R p \left(\pi_\Sigma(\theta) - \pi_\Sigma^+(\theta)\right) \frac{\tau_{y,t-1}}{\Delta g_y(d_{t-1}, y_{t-1}/\theta_{t-1}^+)}$$

$$\left(\text{Insurance value} \quad I(\theta) = \sum_{s=i+1}^{N} \pi(\theta_s) \frac{1}{v_c(\theta_s)} - (1 - \pi_\Sigma(\theta)) \sum_{s=1}^{N} \pi(\theta_s) \frac{1}{v_c(\theta_s)}\right)$$

Labor and savings wedge

- labor wedge

$$\tau_y(\theta) = \Big(g_y\left(d(\theta), 1 - y(\theta)/\theta^+\right) - g_y\left(d(\theta), 1 - y(\theta)/\theta\right)\Big) q(\theta^+) \big/ (p_j \pi(\theta))$$

- value of relaxing incentive constraint, $q(\theta^+)$

$$q(\theta^+) = I(\theta) + \beta R p \left(\pi_\Sigma(\theta) - \pi_\Sigma^+(\theta)\right) \frac{\tau_{y,t-1}}{\Delta g_y(d_{t-1}, y_{t-1}/\theta_{t-1}^+)}$$

- savings wedge

$$\tau_s(\theta^t) = \frac{\left(\sum \pi(\theta_{t+1}|\theta_t)\left(v_c(c(\theta^{t+1}))\right)^{-1}\right)^{-1}}{\sum \pi(\theta_{t+1}|\theta_t) v_c(c(\theta^{t+1}))} - 1$$

(Rogerson (1985); Golosov, Troshkin, Tsyvinski (2016))

Robustness and extensions

Conclusion Recap

- Housing supply

  fixed supply, land permit

- Preferences

  home work and leisure, general, necessity, present bias, home productivity

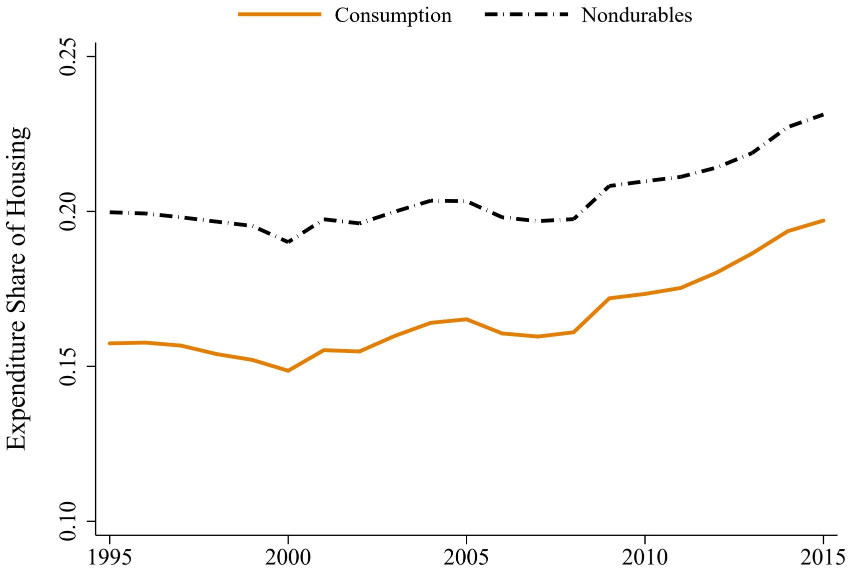
- Frictions

  limited commitment, production externality

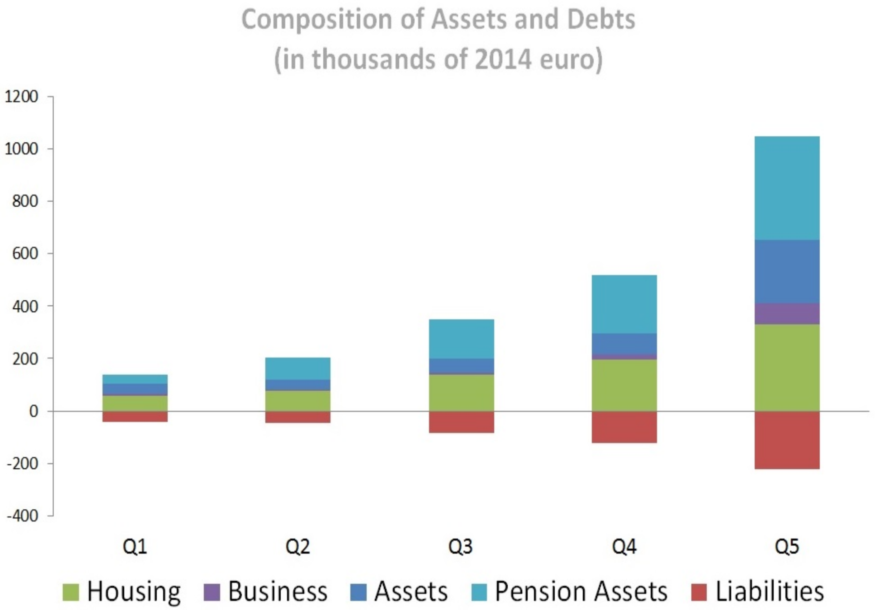
- Political economy

  bargaining

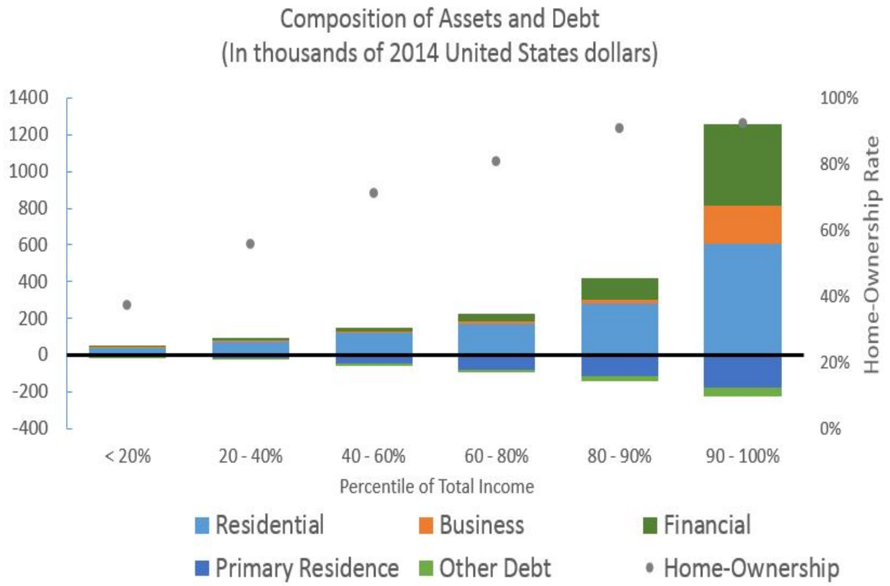
Expenditure share of housing



Household wealth, 2014



Household Wealth in the United States



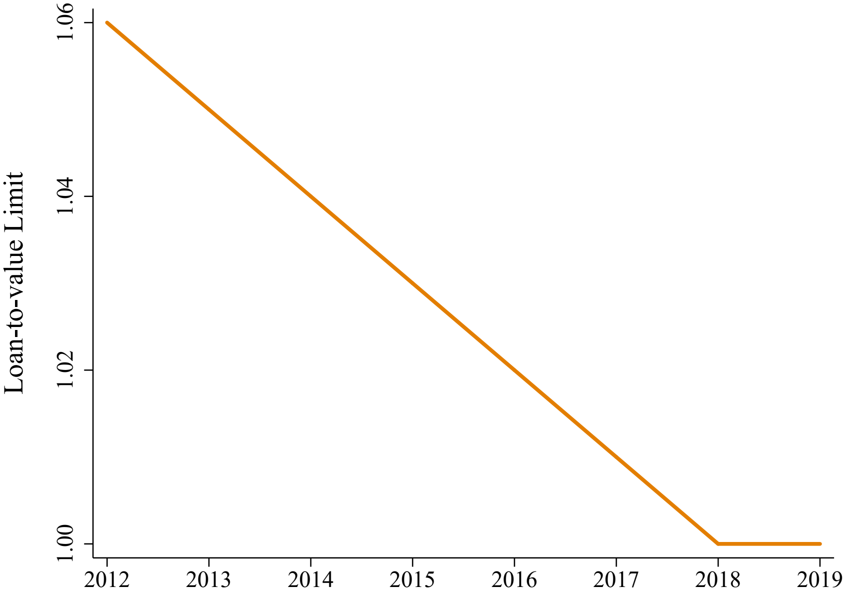
Population, Employment, Hours, 2006−2014

Population in millions	
All ages	16.57
Ages 16 to 64	10.88
Population growth (%)	
All ages	0.35
Ages 16 to 64	0.05
Annual hours per worker	1,424
Annual hours per person	1,148

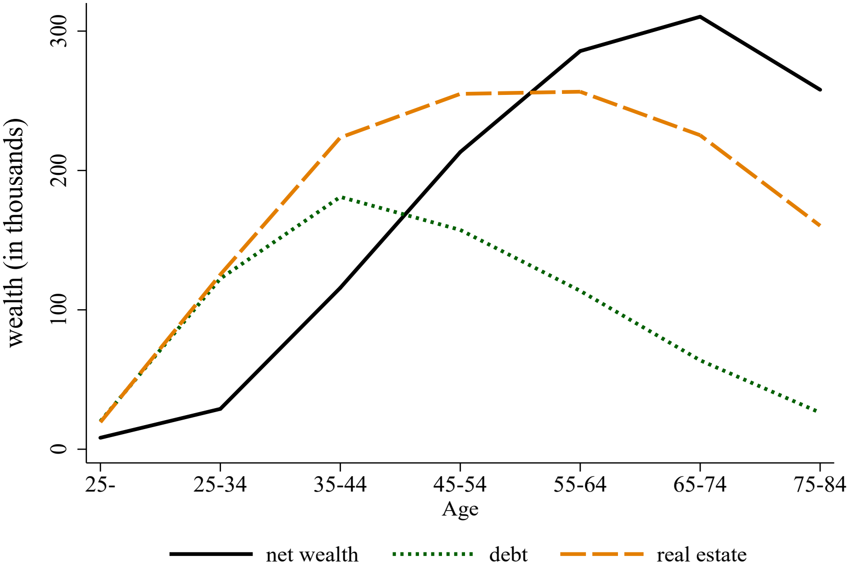
Marginal Tax Rate Brackets, 2017

Lower (in euro)	Upper (in euro)	Worker (in %)	Retiree (in %)
Labor Earnings			
	19,982	36.55	18.65
19,983	33,791	40.80	22.90
33,792	67,072	40.80	40.80
67,073		52.00	52.00
Assets			
	50,000	0.00	0.00
50,000		30.00	30.00

Loan-to-value



Wealth over the life cycle



Policy in the United States, 2014–2018

Federal

- Personal tax receipts **1543 bln**
- Tax expenditures on housing **276** (18%)
  - Home mortgage interest deduction: 101 (#2)
  - Imputed rent 76 (#4)
  - Residential capital gains on home sales 46 (#9)
  - Deductibility of state and local property tax 25 (#16)
  - Others: 28 (#19), (#25), (#37), (#46)

State and Local

- Current tax receipts **1660 bln**
- Property tax receipts **517*** (31%)

Specification of home production technology

- General Beckerian framework with $i = 1, ..., N$ commodities:

$$\max_{\{c_i, n_i\}_{i=1}} \sum_{i=1} U_i(x_1, ..., x_N),$$

$$x_i = F_i(c_i, n_i) \quad \forall i = 1, ..., N,$$

$$\sum_{i=1} p_i c_i = wn, \text{ with } \sum_{i=1} n_i = 1.$$

- My specification is a special case with $N = 2$ commodities:

$$\max_{c,d,n,\ell} U_1(x_1) + U_2(x_2),$$

$$x_1 = F_1(c) \text{ and } x_2 = F_2(d, \ell),$$

$$c + pd = wn, \text{ with } \ell = 1 - n.$$

Preferences in housing literature

Inelastic labor supply, $u(c, d)$

Gervais (2002), Yang (2008), Chambers, Garriga, Schlagenhauf (2009), Fernández-Villaverde, Krueger (2011), Kaplan, Violante (2014), Berger, Vavra (2015), Favilukis, Ludvigson, van Nieuwerburgh (2016), Sommer, Sullivan (2018), Garriga, Hedlund (2019), Garriga, Manuelli, Peralta-Alva (2019), Guren, McKay, Nakamura, Steinsson (2019), Kaplan, Mitman, Violante (2019)

$\Longrightarrow$ Lump-sum taxes

Weakly separable, $u(g(c, d), \ell)$

Davis, Heathcote (2005), Favilukis, Mabille, van Nieuwerburgh (2019)

$\Longrightarrow$ Uniform commodity taxation

Home production, $u(c, g(d, \ell))$

Greenwood, Hercowitz (1991), Benhabib, Rogerson, Wright (1991)

Alternative preferences

- Housing in home production, $u(c, g(d, \ell))$

  $\implies$ tax housing when house complements leisure in home production

- Non-housing in home production, $u(d, g(c, \ell))$

  $\implies$ subsidize consumption when substitutes with leisure in home production

- Inelastic labor supply, $u(c, d)$

  $\implies$ Lump-sum taxes

- Weakly separable, $u(g(c, d), \ell)$

  $\implies$ Uniform commodity taxation

Housing consumption subsidized under current tax policy

Necessity

- time and expenditures produce goods

$$u(c, d, \ell) = v(c) + g(d - \underline{d}, \ell)$$

- home production technology

$$g(d, \ell) = \mathcal{G}\Big(\big(\omega (d - \underline{d})^{\frac{\sigma-1}{\sigma}} + (1 - \omega)\, \ell^{\frac{\sigma-1}{\sigma}} \big)^{\frac{\sigma}{\sigma-1}} \Big)$$

- results carry through

  isomorphic problem by change of variables, $\hat{d} \equiv d - \underline{d}$

General preferences

- housing tax

$$\tau_d(\theta) = \Delta u_d \left(c(\theta), d(\theta), 1 - y(\theta)/\theta^+\right) \underbrace{q(\theta^+)}_{\text{value of relaxing IC}} / (p_j \pi(\theta))$$

- consumption tax

$$\tau_c(\theta) = \Delta u_c \left(c(\theta), d(\theta), 1 - y(\theta)/\theta^+\right) q(\theta^+)/\pi(\theta)$$

- transaction tax

$$\tau_t(\theta) = \Phi_2(d(\theta), d_-)\left(\underbrace{\frac{1}{\beta R}\frac{u_c/(1+\tau_c)}{u_c(\theta)/(1+\tau_c(\theta))}}_{\text{premium}} - \underbrace{1}_{\text{payout}}\right)$$

Home productivity differences

If home productivity is perfectly correlated with market productivity

$$u(c, d, \ell) = v(c) + g(d, \theta\ell)$$

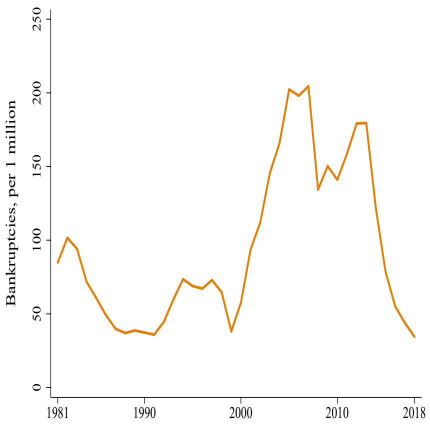
- housing tax

$$\tau_d(\theta) = \Delta g_d\left(d(\theta), \theta^+ - y(\theta)\right) \underbrace{q(\theta^+)}_{\text{value of relaxing IC}} / (p_j \pi(\theta))$$

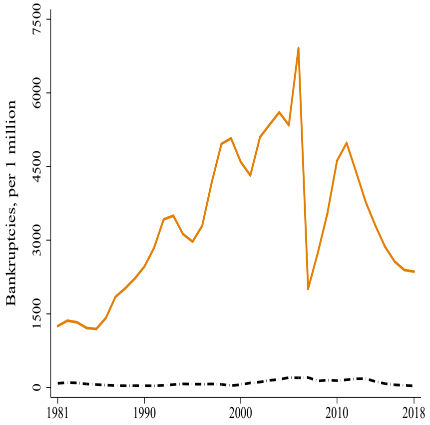
- transaction tax

$$\tau_t(\theta) = \Phi_2(d(\theta), d_-)\left(\underbrace{\frac{1}{\beta R}\frac{u_c)}{u_c(\theta)}}_{\text{premium}} - \underbrace{1}_{\text{payout}} \right)$$

Household bankruptcy

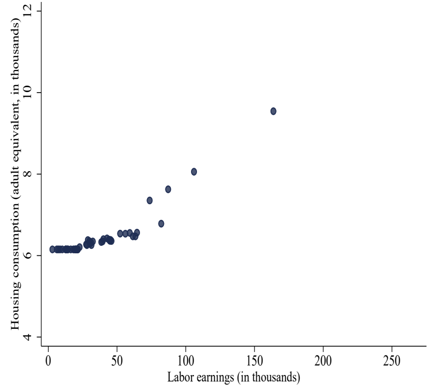


(a) The Netherlands

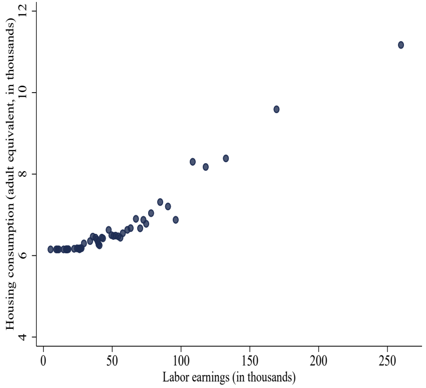


(b) United States

Engel curves



(a) 35–40



(b) 45–50

Definitions

- allocation for household $i \equiv (\underbrace{j, \theta^{t-1}}_{\text{birth year, private skill history}})$ is $x(i) \equiv \{x_{j+v}(\theta^{t+v})\}_{v=0}^{T-t}$

  $x \equiv (c, d, y)$

- set of households $\mathcal{I} \equiv \left\{ \underbrace{\{(0, \theta^{t-1})\}_{t=1}^{T}}_{\text{current generations}}, \overbrace{\{(j, \theta_0)\}_{j=1}^{\infty}}^{\text{future generations}} \right\}$

- an allocation is feasible iff it is resource and incentive feasible

Solving Planner Problem

Efficient allocation

$$\max \; F\left(K_1, Y_1\right) + RB_1 - C_1 - I_1^K - I_1^H - G_1 - \Phi_1 - B_2$$

subject to

- resource feasible

$$F\left(K_j, Y_j\right) + RB_j = C_j + I_j^K + I_j^H + G_j + \Phi_j + B_{j+1} \qquad \forall\, j > 1$$

$$D_j = \chi H_j \qquad \forall\, j$$

- incentive feasible (truth-telling)

$$x(i) \in X_{IC}(i) \qquad \forall\, i$$

- promise keeping

$$\mathcal{V}(i) \leq \mathcal{V}(x(i); i) \qquad \forall\, i$$

No Ponzi, No Arbitrage

- No Ponzi condition

$$\lim_{J \to \infty} \tfrac{1}{R^{J-1}} (B_J + H_J + K_J) \geq 0$$

- No Arbitrage condition

$$F_K(K_j, Y_j) + (1 - \delta^K) = R \qquad \Longrightarrow \qquad r + \delta^K = F_K(K_j, Y_j)$$

- Simplifying assumption

$$r + \delta^H = \chi$$

Fixed supply

$$\max \; F(K_1, Y_1) + RB_1 - C_1 - I_1^K - G_1 - \Phi_1 - B_2$$

subject to

- resource feasible

$$F(K_j, Y_j) + RB_j = C_j + I_j^K + G_j + \Phi_j + B_{j+1} \qquad \forall j > 1$$

$$D_j = \chi \bar{H} \qquad \forall j$$

- incentive feasible

$$x(i) \in X_{IC}(i) \qquad \forall\, i \in \mathcal{I}$$

- promise keeping

$$\mathcal{V}(i) \le \mathcal{V}(x(i); i) \qquad \forall\, i \in \mathcal{I}$$

Land permits

$$\max \; F(K_1, Y_1) + RB_1 - C_1 - I_1^K - I_1^H - G_1 - \Phi_1 - B_2$$

subject to

- resource feasible

$$F(K_j, Y_j) + RB_j = C_j + I_j^K + I_j^H + G_j + \Phi_j + B_{j+1} \qquad \forall j > 1$$

$$D_j = \chi H_j \qquad \forall j$$

$$\bar{L} \geq H_{j+1} - H_j \qquad \forall j$$

- incentive feasible

$$x(i) \in X_{IC}(i) \qquad \forall\, i \in \mathcal{I}$$

- promise keeping

$$\mathcal{V}(i) \leq \mathcal{V}(x(i); i) \qquad \forall\, i \in \mathcal{I}$$

Planner Problem

The Lagrangian is linearly separable in $x(i)$.

Given values $\mathcal{V}(\mathcal{I})$, solve:

$$\max \sum_{j=1}^{\infty} \frac{1}{R^{j-1}} \Big(wY_j - C_j - D_j - \Phi_j - G_j \Big) + R\Big(K_1 + B_1 + H_1 \Big)$$

subject to

- resource feasible

$$D_j = \chi H_j \qquad (p_j) \qquad \forall j = 1, \ldots, \iota$$

- incentive feasible

$$x(i) \in X_{IC}(i) \qquad \forall\, i \in \mathcal{I}$$

- promise keeping

$$\mathcal{V}(i) \leq \mathcal{V}_j\big(x(i); \theta^{t-1}\big) \qquad \forall\, i \in \mathcal{I}$$

Component Planner Problem

Since the Lagrangian is linearly separable in $x(i)$

Given value $\mathcal{V}(i)$, solve:

$$\max \sum_{t,\theta^t} \pi(\theta^t)\Big(wy(\theta^t) - c(\theta^t) - p_j d(\theta^t) - \Phi\left(d(\theta^t), d(\theta^{t-1})\right)\Big)\Big/ R^{t-1}$$

subject to

- incentive feasible

$$x(i) \in X_{IC}(i)$$

- promise keeping

$$\mathcal{V}(i) \leq \mathcal{V}_j\left(x(i); \theta^{t-1}\right)$$

Incentive Compatible

- reporting strategy $\sigma \equiv \{\sigma_t(\theta^t)\}_{\Theta^t,t}$, with history $\sigma^t = (\sigma_1, \ldots, \sigma_t)$
- corresponding allocation $x^\sigma \equiv \{x_t(\sigma^t(\theta^t))\}_{\Theta^t,t}$
- continuation utility given reporting strategy σ

  $$V^\sigma(\theta^t) = u\left(x_t(\sigma^t(\theta^t)); \theta_t\right) + \beta \sum \pi\left(\theta_{t+1}|\theta_t\right) V^\sigma(\theta^{t+1})$$

- truthful reporting strategy, $\sigma_t(\theta^t) = \theta_t \; \forall \theta^t$, generating $V(\theta^t)$
- incentive compatibility, $X_{IC}(i)$

  $$V(\theta^t) \geq V^\sigma(\theta^t) \qquad \forall \theta^t, \; \forall \sigma \in \Sigma$$

Local Downward Incentive Constraints

- continuation utility given one-shot deviation strategy σ^l

$$V^{\sigma^l}(\theta^t) = u\left(x_t(\theta^{t-1}, l); \theta_t\right) + \beta \sum \pi\left(\theta_{t+1} | \theta_t\right) V^{\sigma^l}(\theta^{t-1}, l, \theta_{t+1})$$

- incentive compatibility with one-shot deviations $(\forall \theta^t, \sigma^l)$

$$\begin{aligned} V(\theta^t) &= \max_l \; V^{\sigma^l}(\theta^t) \\ &= \max_l \; u(x_t(\theta^{t-1}, l); \theta_t) + \beta \sum \pi\left(\theta_{t+1} | \theta_t\right) V(\theta^{t-1}, l, \theta_{t+1}) \end{aligned}$$

- local downward incentive constraints, $X_{LD}(i)$

$$\begin{aligned} & u(x_t(\theta^{t-1}, \theta_t); \theta_t) + \beta \sum \pi\left(\theta_{t+1} | \theta_t\right) V(\theta^{t-1}, \theta_t, \theta_{t+1}) \\ \geq\; & u(x_t(\theta^{t-1}, \theta_t^-); \theta_t) + \beta \sum \pi\left(\theta_{t+1} | \theta_t\right) V(\theta^{t-1}, \theta_t^-, \theta_{t+1}) \qquad \forall \theta^t \end{aligned}$$

Relaxed Component Planner Problem

Since the Lagrangian is linearly separable in $x(i)$

Given value $\mathcal{V}(i)$, solve:

$$\max \sum_{t,\theta^t} \pi(\theta^t)\Big(wy(\theta^t) - c(\theta^t) - p_j d(\theta^t) - \Phi\left(d(\theta^t), d(\theta^{t-1})\right)\Big)\Big/ R^{t-1}$$

subject to

- incentive feasible

$$x(i) \in X_{LD}(i)$$

- promise keeping

$$\mathcal{V}(i) \leq \mathcal{V}_j\left(x(i); \theta^{t-1}\right)$$

Recursive Problem: States and Incentive Constraints

- continuation value

$$\mathcal{V}(\theta^t) \equiv \sum \pi(\theta_{t+1}|\theta_t) V(\theta^{t+1})$$

- threat value

$$\tilde{\mathcal{V}}(\theta^t) \equiv \sum \pi(\theta_{t+1}|\theta_t^+) V(\theta^{t+1})$$

continuation value given a one-time local deviation

- recursive local downward incentive constraints

$$u(x_t(\theta^{t-1}, \theta_t); \theta_t) + \beta \sum \pi\left(\theta_{t+1}|\theta_t\right) V(\theta^{t-1}, \theta_t, \theta_{t+1})$$

$$\geq u(x_t(\theta^{t-1}, \theta_t^-); \theta_t) + \beta \sum \pi\left(\theta_{t+1}|\theta_t\right) V(\theta^{t-1}, \theta_t^-, \theta_{t+1}) \qquad \forall \theta^t$$

Recursive Problem: States and Incentive Constraints

- continuation value

  $\mathcal{V}(\theta^t) \equiv \sum \pi(\theta_{t+1}|\theta_t)V(\theta^{t+1})$

- threat value

  $\tilde{\mathcal{V}}(\theta^t) \equiv \sum \pi(\theta_{t+1}|\theta_t^+)V(\theta^{t+1})$

  continuation value given a one-time local deviation

- recursive local downward incentive constraints

$$u\left(x_t(\theta^{t-1}, \theta_t); \theta_t\right) + \beta\mathcal{V}(\theta^{t-1}, \theta_t)$$

$$\geq u\left(x_t(\theta^{t-1}, \theta_t^-); \theta_t\right) + \beta\tilde{\mathcal{V}}(\theta^{t-1}, \theta_t^-) \qquad \forall \theta^t$$

Recursive Problem

Choose $\left(x_t(\theta), \mathcal{V}_t(\theta), \tilde{\mathcal{V}}_t(\theta)\right)$ to solve

$$\Pi_t(\mathcal{V}, \tilde{\mathcal{V}}, d, \theta_-) = \max \sum \pi(\theta|\theta_-)\Big(wy_t(\theta) - c_t(\theta) - p_j d_t(\theta) - \Phi\left(d_t(\theta), d\right) + \Pi_{t+1}(\mathcal{V}_t(\theta), \tilde{\mathcal{V}}_t(\theta^+), d_t(\theta), \theta)/R\Big)$$

subject to

- promise keeping

$$\mathcal{V} = \sum \pi(\theta|\theta_-)\big(u\left(x_t(\theta); \theta\right) + \beta\mathcal{V}_t(\theta)\big)$$

- threat keeping

$$\tilde{\mathcal{V}} = \sum \pi(\theta|\theta_-^+)\big(u\left(x_t(\theta); \theta\right) + \beta\mathcal{V}_t(\theta)\big)$$

- incentive constraints

$$u\left(x_t(\theta); \theta\right) + \beta\mathcal{V}_t(\theta) \geq u\left(x_t(\theta^-); \theta\right) + \beta\tilde{\mathcal{V}}_t(\theta) \qquad \forall\theta$$

Newton-Raphson algorithm

Given a state (ν, μ, d, θ_-), $6N$ unknowns

- Guess $\{c_i\}_{N-1}, \{d_i\}_N$
- Optimality $\{c_i\}_N \implies \{c_N, \{q_i\}_{N-1}\}$
  exploits separability $v(c)$
- Optimality $\{\mathcal{V}_i\}_N, \{\tilde{\mathcal{V}}_i\}_{N-1} \implies \{\nu_i\}_N, \{\mu_i\}_{N-1}$
  imply continuation values
- Optimality y_N and incentive constraints $\implies \{y_i\}_N$
- Residual equations: optimality $\{d_i\}_N, \{y_i\}_{N-1}$
- Determine $\mathcal{V}, \tilde{\mathcal{V}}$ using promise and threat-keeping condition

Parallelize

Optimality conditions

Given a history θ^t

- Labor wedge

$$-\frac{u_{y,t}(\theta)}{u_{c,t}(\theta)} \equiv w\frac{1-\tau_{yi}}{1+\tau_c}$$

- Savings wedge

$$u_{c,t}(\theta) \equiv \beta R \sum \pi\left(\theta'|\theta\right)\left(1 - \tau_{ai}/R\right)u_{c,t+1}(\theta')$$

- Housing wedge

$$\frac{u_{d,t}(\theta)}{u_{c,t}(\theta)} \equiv \frac{1+\tau_{di}}{1+\tau_c} + \frac{\Phi_1(\theta)}{1+\tau_c} + \frac{\tau_{ti}^1}{1+\tau_c} + \beta \sum \pi\left(\theta'|\theta\right)\left(\frac{\Phi_2(\theta')}{1+\tau_c} + \frac{\tau_{ti}^2}{1+\tau_c}\right)\frac{u_c(\theta')}{u_c}$$

House price to decentralize

- Planner's shadow price for housing services p_j
- Rental firm optimality

  $$\hat{p}_j = \frac{1}{\chi}(r + \hat{\delta} - \hat{\pi}^H_{j+1})\hat{p}^H_j$$

- Construction firm optimality implies $\hat{p}^H_j = 1 \;\; \forall j > \iota$
- Equate $\hat{p}_j$ to p_j to obtain house price path

  $$\hat{p}^H_j = 1 + \sum_{s=j}^{\iota} \frac{\phi_s}{R^{s-j+1}}$$

  where ϕ_s is the multiplier on predetermined housing constraints

Algorithm

- Guess $\mathcal{V}(\mathcal{I})$
  1. Guess $\{p_j\}$
     1. Solve a component planner for every i given $\mathcal{V}(i)$, giving $x(i)$
     2. Aggregate and evaluate housing services constraints
     3. Update $\{p_j\}$
  2. Aggregate $x(i)$ and evaluate the objective function
- Update $\mathcal{V}(\mathcal{I})$

Two Stage Example

Component planner

Solve version with one cohort, two types in second period (θ_L, θ_H)

$$\max_{c,d,y} \; wy_0 - c_0 - pd_0 + \sum \pi_i \Big(wy_i - c_i - pd_i - \Phi(d_i, d_0) \Big) \Big/ R$$

subject to

$$u(c_0, d_0, y_0; \theta_0) + \beta(\pi_H u\,(c_H, d_H, y_H; \theta_H) + \pi_L u\,(c_L, d_L, y_L; \theta_L)\,) \geq \mathcal{V}$$

$$u(c_H, d_H, y_H; \theta_H) \geq u(c_L, d_L, y_L; \theta_H)$$

Characterize efficient distortions, analyze motives for taxation

Efficient housing consumption tax, τ_d^c

- $\tau_{dL}^c \geq 0$ if and only if $\sigma \leq 1$

- Prevent H from mimicking L

  benefit of deviation is more home production

  depress d_L to discourage deviation

$$\left(\tau_{dL}^c = \left(g_d\left(d_L, 1 - y_L/\theta_H\right) - g_d\left(d_L, 1 - y_L/\theta_L\right)\right)\frac{\pi_H}{\pi_L p}\left(\frac{1}{v_c(c_H)} - \sum \pi_i \frac{1}{v_c(c_i)}\right)\right)$$

Efficient transaction tax

- $\tau_{di}^{t} \geq 0$ if and only if $v_c(c_0) \geq \beta R v_c(c_i)$
- Suppose $\sigma = 1$, then efficient to equate MRS and MRT
- $\tau_{di}^{t} = \Phi_2(d_i, d_0)\left(\frac{1}{\beta R}\frac{v_c(c_0)}{v_c(c_i)} - 1\right)$
- precautionary owner lives in smaller house due to concerns over selling fee in bad state
- implicitly subsidize through transaction tax

Disability Insurance

Component planner for disability insurance

Simplify to separable preferences, proportional adjustment costs Φ

$$\max_{c,d,y} \; y_0 - c_0 - d_0 + \sum \pi_i \Big(y_i - c_i - d_i - \Phi d_0 \Big) \Big/ R$$

subject to

$$u(c_0, d_0, y_0; \theta_0) + \beta(\pi_H u\,(c_H, d_H, y_H; \theta_H) + \pi_L u\,(c_L, d_L, 0)\,) \geq \mathcal{V}$$

$$u(c_H, d_H, y_H; \theta_H) \geq u(c_L, d_L, 0)$$

Characterize efficient distortions, study implementation with taxes

Implementation for disability insurance

The efficient allocation x is individually optimal given tax system $\mathbf{T}$

$$T(Rs_1, y_1, d_1) = \begin{cases} \tau_H^s Rs_1 + \tau_H^l + \tau_H^t d_1 & \text{if } \; y_1 > 0 \\ \tau_L^s Rs_1 + \tau_L^l + \tau_L^t d_1 & \text{otherwise} \end{cases}$$

- $\tau_i^s = -\left(\frac{1}{\beta R}\frac{v_c(c_0)}{v_c(c_i)} - 1\right)$
- $\tau_i^l = y_i - c_i - d_i + (1 - \tau_i^s)Rs_i - \tau_i^t d_i - \Phi d_i$
- $\tau_i^t = \Phi\left(\frac{1}{\beta R}\frac{v_c(c_0)}{v_c(c_i)} - 1\right)$

Double deviation

Why use the transaction tax ex-post?

- Alternative transaction tax

$$\frac{u_d}{u_c} \equiv 1 + \hat{\tau}_t + \beta \left[\pi_H \frac{u_c(c_H)}{u_c(c_0)} + \pi_L \frac{u_c(c_L)}{u_c(c_0)} \right] \Phi$$

- Double deviation

$$\frac{\Delta}{u_c} = 1 + \hat{\tau}_t + \beta \frac{u_c(c_L)}{u_c(c_0)} \Phi - \frac{u_d}{u_c} > 0$$

Report L in any case; downsize in period 1

“Ricardian equivalence”

Back

How does tax policy relax the borrowing constraint?

- Savings s_1 increase one-for-one in endowment s_0
- Tax receipts in final period increase by Rs_1
- Borrowing constraint relaxed in Ricardian fashion
- Government debt increases to finance endowment

Component planner with limited commitment

$$\max_{c,d,y} \quad wy_0 - c_0 - pd_0 + \sum \pi_i \Big(wy_i - c_i - pd_i - \Phi(d_i, d_0) \Big) \Big/ R$$

subject to

$$u(c_0, d_0, y_0; \theta_0) + \beta(\pi_H u\,(c_H, d_H, y_H; \theta_H) + \pi_L u\,(c_L, d_L, y_L; \theta_L)\,) \geq \mathcal{V}$$

$$u(c_H, d_H, y_H; \theta_H) \geq u(c_L, d_L, y_L; \theta_H)$$

$$u(c_H, d_H, y_H; \theta_H) \geq \mathcal{V}_H$$

$$u(c_L, d_L, y_L; \theta_L) \geq \mathcal{V}_L$$

$\implies$ Housing consumption tax and transaction tax unchanged

Component planner with production externality

Production externality, $F(K, Y) + \zeta D$

$$\max_{c,d,y} \quad wy_0 - c_0 - (p - \zeta)d_0 + \sum \pi_i \Big(wy_i - c_i - (p - \zeta)d_i - \Phi(d_i, d_0) \Big) \Big/ R$$

subject to

$$u(c_0, d_0, y_0; \theta_0) + \beta(\pi_H u\,(c_H, d_H, y_H; \theta_H) + \pi_L u\,(c_L, d_L, y_L; \theta_L)\,) \geq \mathcal{V}$$

$$u(c_H, d_H, y_H; \theta_H) \geq u(c_L, d_L, y_L; \theta_H)$$

$\implies$ Level shift in housing consumption tax

$$\tau_d(\theta) = -\zeta/p_j + \Delta g_d\,(c(\theta), d(\theta), 1 - y(\theta)/\theta^+)\,q(\theta^+)/(p_j \pi(\theta))$$

Inverse Euler equation with present bias

- Inverse Euler equation (component problem is identical)

$$\frac{1}{v_c(c_0)} = \frac{1}{\beta R} \sum \pi_i \frac{1}{v_c(c_i)}$$

- Household Euler equation

$$v_c(c_0) = \beta R \, \delta \, (1 - \tau_s) \sum \pi_i v_c(c_i)$$

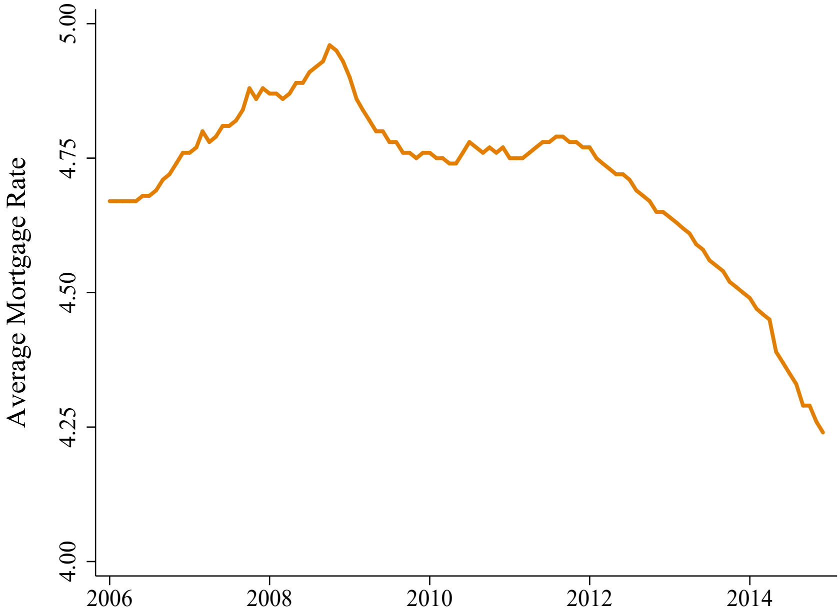
- Savings wedge

$$1 - \tau_s = \underbrace{\frac{1}{\delta}}_{\text{bias} > 1} \times \underbrace{\frac{1}{\sum \pi_i v_c(c_i) \sum \pi_i \frac{1}{v_c(c_i)}}}_{\text{Jensen's inequality} < 1}$$

Present bias is force towards subsidy, not differential subsidy

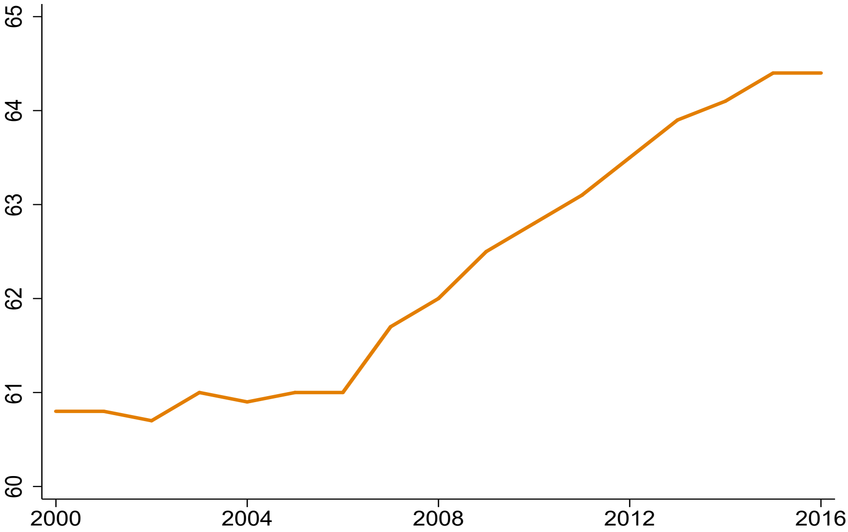
Nominal average mortgage rate

User cost Back



Average retirement age

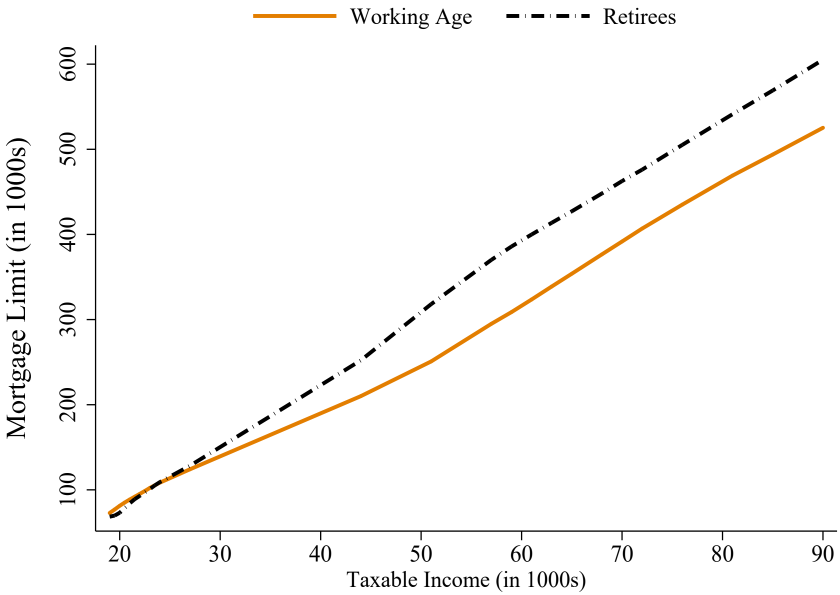
Back



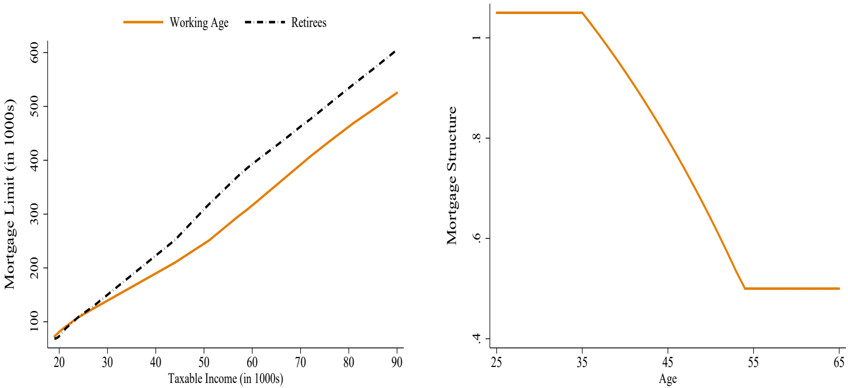
Boerma and Heathcote (2019)

Mortgage regulation

Back



Loan-to-Income and Loan-to-Value



Wage Dynamics

Wages

- Bin households in 6 groups based on their training
  - High school or vocational (Low)
  - University of applied sciences (Medium)
  - University (High)

- Construct hourly wage rate

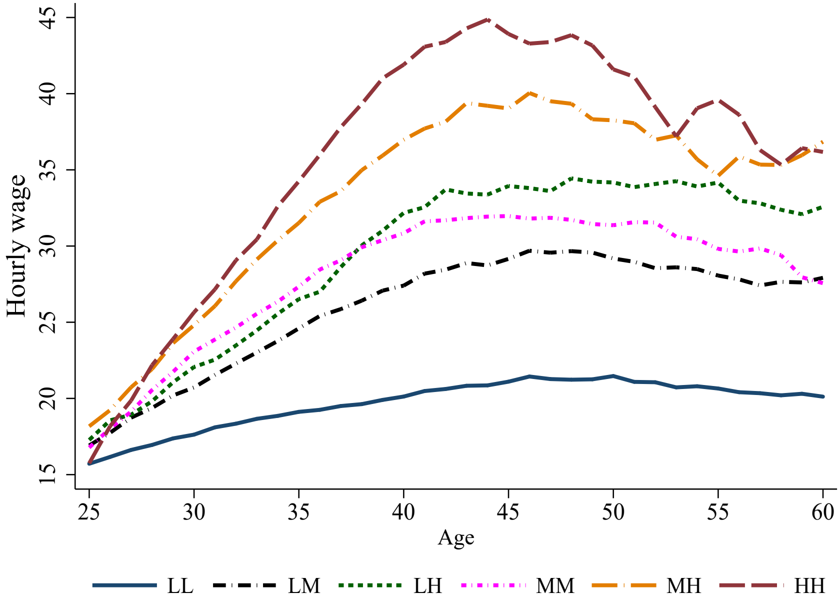
$$W_{ijt} = A_j \exp\left(\tilde{w}_{ijt}\right)$$

A_j is time effect and $\tilde{w}_{ijt}$ is individual specific wage

- Construct residual wage z_{ijt} from regression

$$\log W_{ijt} = \mathbf{A}_j + \mathbf{X}_{ijt} + z_{ijt}$$

Wage Profiles



Wage Dynamics

- Assume wage process is time-invariant
- Statistical model for wages

$$\log z_{it} = \log \theta_{it} + \varepsilon_{it}$$

$$\log \theta_{it} = \rho \log \theta_{it-1} + u_{it}$$

$$\varepsilon_{it} \sim \mathcal{N}(0, \sigma_{\varepsilon}^2)$$

$$u_{it} \sim \mathcal{N}(0, \sigma_{u}^2)$$

$$z_{i0} \sim \mathcal{N}(0, \sigma_{z_0}^2)$$

with innovations (i) iid across individuals

(ii) orthogonal to one another

(iii) independent across time

Proof of Identification

1. Autoregressive coefficient

$$\rho = \frac{\text{Cov}(\log z_{it}, \log z_{it-2})}{\text{Cov}(\log z_{it-1}, \log z_{it-2})}$$

2. Variance of transitory innovation

$$\sigma_\varepsilon^2 = \text{Var}(\log z_{it}) - \frac{1}{\rho}\text{Cov}(\log z_{it+1}, \log z_{it})$$

3. Variance of initial shock

$$\sigma_{z0}^2 = \text{Var}(\log z_{i0}) - \sigma_\varepsilon^2$$

4. Variance of persistent innovation

$$\sigma_u^2 = \text{Var}(\log z_{it-1}) - \text{Cov}(\log z_{it}, \log z_{it-2}) - \sigma_\varepsilon^2$$

Wage Process Estimates

Education	Persistence, ρ	Innovation, σ_u^2
Low, Low	0.9542	0.0096
Low, Medium	0.9660	0.0087
Low, High	0.9673	0.0162
Medium, Medium	0.9570	0.0099
Medium, High	0.9616	0.0109
High, High	0.9564	0.0172

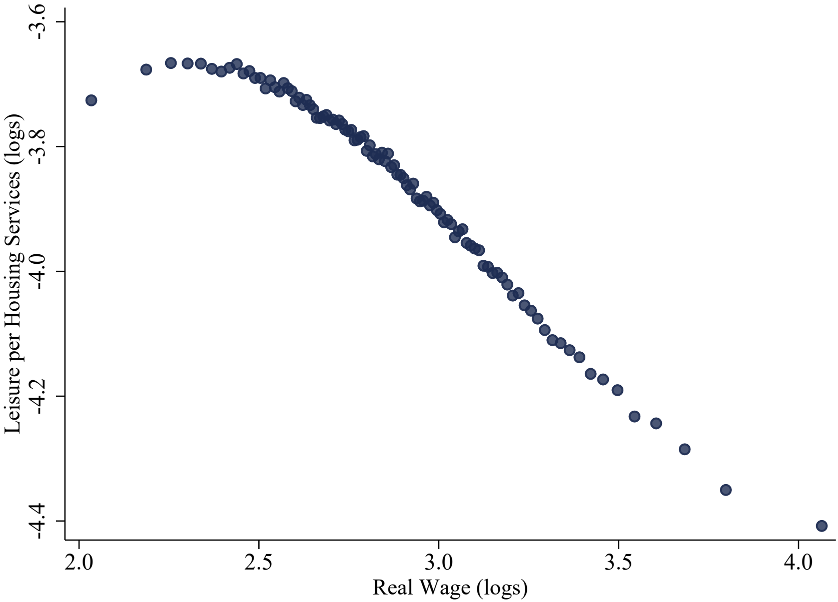
Calibrated parameters

Back

Parameter	Value	Data Target
T	53	Median life expectancy of 77
T_r	40	Median retirement age of 63
r	0.031	Mean interest rate on mortgage loans
α	0.439	Capital income share
δ^K	0.061	Depreciation rate of business capital
δ	0.024	Depreciation rate of residential structures
χ	0.055	Normalization of benchmark user cost, $r + \delta$
ι	2	Mean building time for new houses
ψ_b	0.020	Mean broker fee, buyers
ψ_s	0.015	Mean broker fee, sellers

CES specification

Back



Gap-based estimator

- Gap

  $x_i \equiv \log\left(\frac{\ell_i}{d_i}\right) - \log\left(\frac{\ell_i^*}{d_i^*}\right)$

  where $*$ denote optimality without taxes and transaction costs

- Choose parameter vector ζ to solve

  $$\min \int \left(\left(f_p^{\text{model}}(x;\zeta) - f^{\text{data}}(x)\right)^2 + \left(h^{\text{model}}(x;\zeta) - h^{\text{data}}(x)\right)^2\right) \mathrm{d}x$$

  with distribution f and hazard h

- Jointly estimate elasticity of substitution σ and moving costs Φ

  (Berger, Vavra (2015))

Alternative approaches

1. Exogenous variation due to 2017 TCJA with PSID 2017, 2019

$$\Delta \log \left(\frac{\ell}{d}\right)_{it} = -\sigma \Delta \log \left(\frac{\hat{w}}{\hat{p}}\right)_{it}$$

where user cost $\hat{p}$ strongly increased due to:

- increased standard deduction, cap on state and local deductions
  e.g. couple deduction from 13 to 24 thousand, cap of 10 thousand
- lowered cap on mortgage interest deduction
  maximum mortgage from 1 million to 750 thousand
- lowered income tax rates, and changed tax brackets

2. Identification from growth rates

$$\Delta \log \left(\frac{\ell}{d}\right)_{it} = -\sigma \Delta \log \left(\frac{w}{p}\right)_{it}$$

Household

Use:

- leisure hours per adult, ℓ
- housing consumption controlling for household characteristics, d

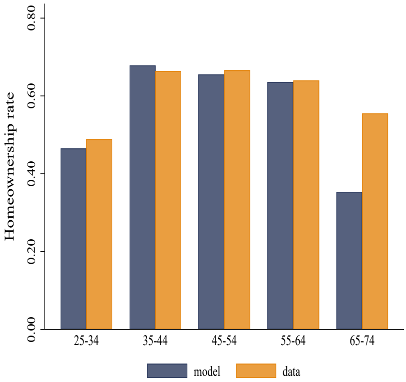
  number of adults, number of children
- hours-weighted average wage rate, w

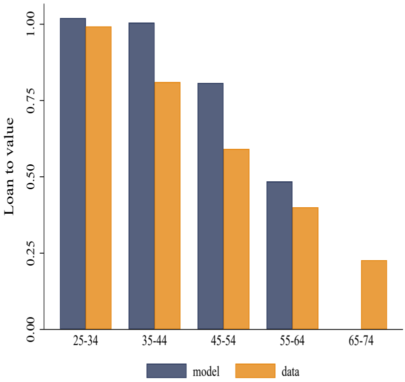
Households that are stable in:

- structure (singles, couples, ...)
- employment (single, dual earner)

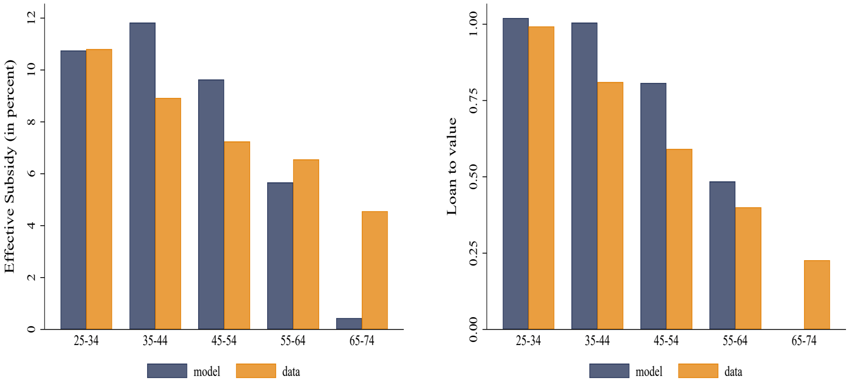
  drop self-employed, institutionalized

Model validation



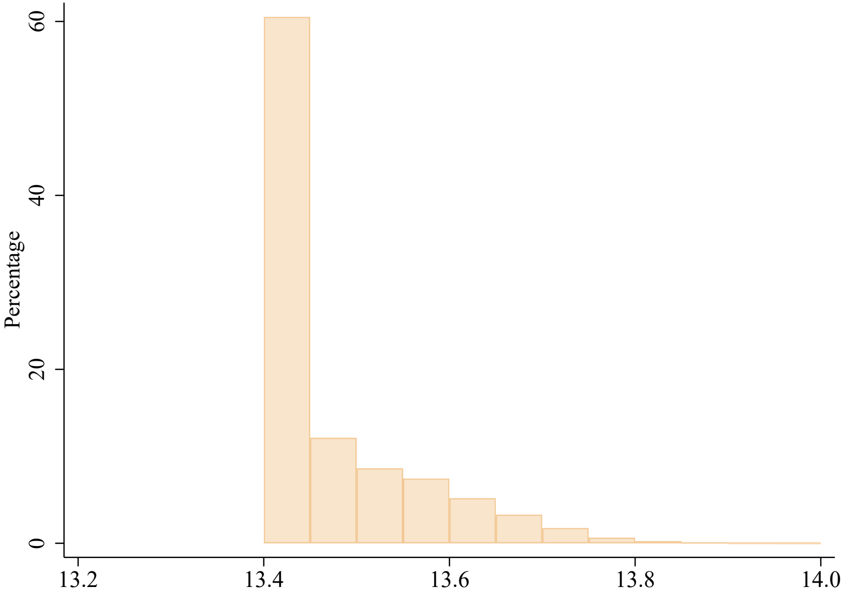


Model user cost

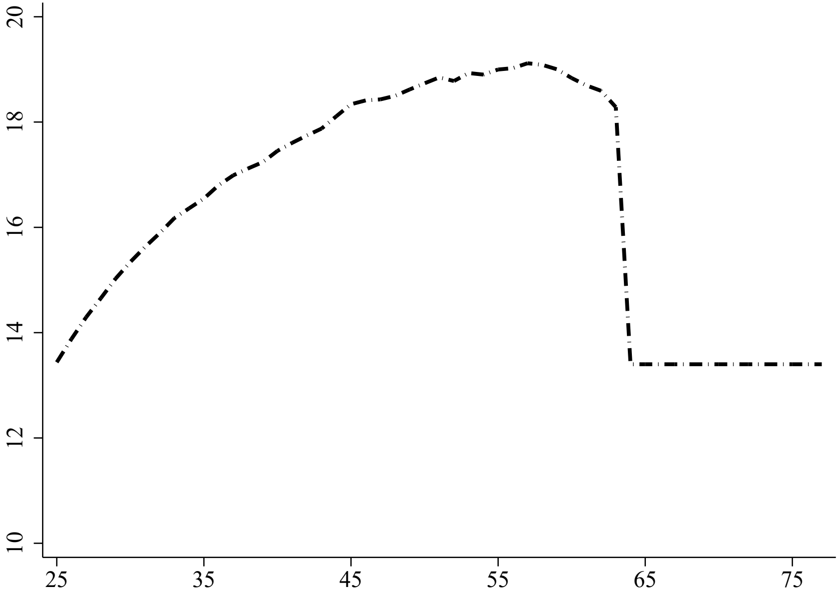


Dispersion consumption tax

Baseline

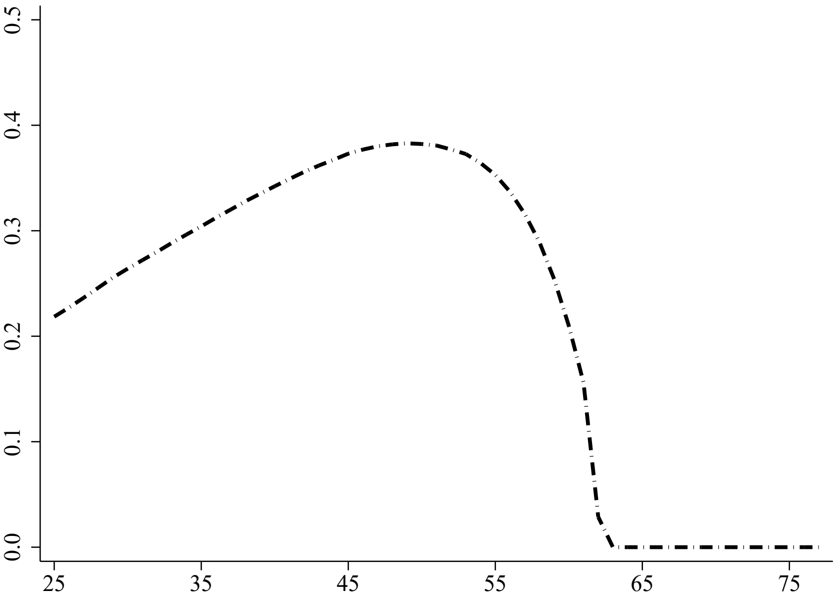


Income tax



Asset tax

Baseline



Variational argument with separable preferences

- Incentive compatible variation (small δ)

  $\uparrow d$ by $\varepsilon_d(\delta)$ to $\uparrow$ housing utility by δ, $\varepsilon_d(\delta) = \delta / g_d(d)$

  $\downarrow c$ by $\varepsilon_c(\delta)$ to $\downarrow$ consumption utility by δ, $\varepsilon_c(\delta) = \delta / v_c(c)$

- Change in objective function

  $$\Pi(\delta) = \frac{\delta}{v_c(c)} - \left(p + \Phi_1\right) \frac{\delta}{g_d(d)} - \frac{1}{R} \sum \pi\left(\theta' | \theta\right) \Phi_2\left(d(\theta'), d\right) \frac{\delta}{g_d(d)}$$

- At optimum, $\partial \Pi(\delta) / \partial \delta = 0$

  $$\frac{g_d(d)}{v_c(c)} = \left(p + \Phi_1\right) + \frac{1}{R} \sum \pi\left(\theta' | \theta\right) \Phi_2\left(d(\theta'), d\right)$$

- Align planner and private optimality condition

  $$\frac{1}{R} \sum \pi\left(\theta' | \theta\right) \Phi_2\left(d(\theta'), d\right) = \beta \sum \pi\left(\theta' | \theta\right) \left(\Phi_2\left(d(\theta'), d\right) + \tau_d^t(\theta')\right) \frac{u_c(\theta')}{u_c}$$

Savings tax

- tax savings in bad states

  $u_c(c_-) \leq \beta R u_c(c(\theta))$

- implementation of inverse Euler equation

  Kocherlakota (2005), Golosov, Tsyvinski (2006)

- discourage savings by increasing after-tax return risk

  in incomplete markets, households reduce savings to reduce exposure

$$\tau_s(\theta) = -\left(\frac{1}{\beta R}\frac{u_c}{u_c(\theta)} - 1\right)$$

Bargaining Solution

Egalitarian Solution

Axioms

1. Monotonicity
2. Anonymity
3. Weak Pareto optimality
4. Invariant to additive utility transformations

A bargaining solution satisfies 1–4 iff it is the egalitarian solution.

Egalitarian solution

$$E(\underline{\mathcal{V}}, \mathbb{V}) \equiv \max \left\{ \mathcal{V} \in \mathbb{V} \mid \underbrace{\mathcal{V}_i - \underline{\mathcal{V}}_i = \mathcal{V}_j - \underline{\mathcal{V}}_j \ \forall \, (i,j) \in (1, \ldots, N)}_{\text{Computational simplicity}} \right\}$$

Axioms

1. Monotonicity

   If $\mathbb{V} \subset \mathbb{V}'$ and $\underline{\mathcal{V}} = \underline{\mathcal{V}}'$, then $\mathcal{F}(\underline{\mathcal{V}}, \mathbb{V}') \geq \mathcal{F}(\underline{\mathcal{V}}, \mathbb{V})$

2. Weak Pareto optimality

   If $\mathcal{V}' \gg \mathcal{F}(\underline{\mathcal{V}}, \mathbb{V})$, then $\mathcal{V}' \notin \mathbb{V}$

3. Anonymity

   Let $\mathcal{P} : \mathbb{R}^N \to \mathbb{R}^N$ be a permutation operator. $\mathcal{F}$ is anonymous if $\mathcal{P}(\mathcal{F}(\underline{\mathcal{V}}, \mathbb{V})) = \mathcal{F}(\mathcal{P}(\underline{\mathcal{V}}), \mathcal{P}(\mathbb{V}))$ for every $(\underline{\mathcal{V}}, \mathbb{V}) \in \mathcal{B}$

4. Invariant to additive utility transformations

   For every $\xi \in \mathbb{R}^N$ and $(\underline{\mathcal{V}}, \mathbb{V})$, $\mathcal{F}(\underline{\mathcal{V}} + \xi, \mathbb{V} + \xi) = \xi + \mathcal{F}(\underline{\mathcal{V}}, \mathbb{V})$

Efficiency with Endogenous Prices

Efficiency Test

If an allocation x does not satisfy

$$\frac{\tau_{l,t}(\theta)}{1-\tau_{l,t}(\theta)} = -\varepsilon_{l,t}(\theta)\frac{1-F^t(\theta|\theta_-)}{\theta f^t\left(\theta|\theta_-\right)}\left(\int_\theta^{\bar{\theta}}\frac{u_c(\theta)}{u_c(\hat{\theta})}\frac{f^t(\hat{\theta}|\theta_-)}{1-F^t(\theta|\theta_-)}\mathrm{d}\hat{\theta} - \int_{\underline{\theta}}^{\bar{\theta}}\frac{u_c(\theta)}{u_c(\hat{\theta})}f^t(\theta|\theta_-)\mathrm{d}\hat{\theta}\right)$$

$$+\beta R\frac{\tau_{y,t-1}}{1-\tau_{y,t-1}}\frac{\varepsilon_{l,t}(\theta)}{\varepsilon_{l,t-1}}\frac{u_c(\theta)}{u_{c,t-1}}\frac{\theta_{t-1}}{\theta}\frac{f^{t-1}\left(\theta_{t-1}|\theta_{t-2}\right)}{f^t\left(\theta|\theta_{t-1}\right)}\int_\theta^{\bar{\theta}} g^t(\hat{\theta}|\theta_-)\mathrm{d}\hat{\theta}\ ,$$

then it is not efficient.

$$\left(\varepsilon_{l,t}(\theta) \equiv 1 + 1/\gamma_{l,t}(\theta)\ ,\ \text{where}\ \ \gamma_{l,t}(\theta) = \frac{u_{ll,t}(\theta)l_t(\theta)}{u_{l,t}(\theta)}\right)$$

Duality

- If an allocation $x(i)$ solves the cost minimization problem given $\mathcal{V}$, then $x(i)$ solves the welfare maximization problem when the resources are $\Pi_j\left(x(i);\theta^{t-1}\right)$. Maximum welfare is $\mathcal{V}$.

- If an allocation $x(i)$ solves the welfare maximization problem given Π, then $x(i)$ solves the cost minimization problem when required welfare is $\mathcal{V}_j\left(x(i);\theta^{t-1}\right)$. Minimum cost is Π.

Welfare maximization

Given i and resources Π, the welfare maximization problem is:

$$\max_{x(i)} \sum_{v=0}^{T-t} \beta^v \int u\Big(c_{s+v}(\theta^{t+v}), d_{s+v}(\theta^{t+v}), y_{s+v}(\theta^{t+v}); \theta_{t+v}\Big) \mathrm{d}F^{t+v}\left(\theta^{t+v} | \theta^{t-1}\right)$$

subject to

$$\mathcal{C}_j(x(i); \theta^{t-1}) \leq \Pi$$

$$x(i) \in \mathcal{X}_{IC}(i)$$

- Dual problem to cost minimization problem

Owner's consumption tax by income, age

Back

Age	Household income (in thousand euro)					
	< 60	60–80	80–120	120–200	> 200	All
25–35	-9.8	-10.7	-11.6	-12.6	-14.1	-10.8
	4.3	3.7	3.3	0.8	0.0	12.1
35–50	-7.1	-7.4	-8.3	-10.2	-11.4	-8.2
	10.4	10.7	15.0	7.4	1.2	44.6
50–65	-5.1	-6.0	-6.8	-8.2	-10.0	-6.7
	7.5	5.3	8.7	5.5	0.9	27.8
> 65	-3.6	-6.4	-7.2	-7.7	-9.5	-4.7
	10.8	2.1	1.8	0.7	0.1	15.5
All	-6.1	-7.6	-8.1	-9.4	-11.0	-7.5
	33.0	21.8	28.8	14.3	2.1	100.0

Home mortgage interest deduction

	< 40	40–75	75–125	125–250	> 250	All
25–35	-13.5	-14.5	-15.5	-17.0	-18.8	-14.6
35–50	-9.9	-10.2	-10.8	-12.6	-14.4	-10.9
50–65	-5.6	-7.0	-7.5	-8.3	-9.5	-7.2
> 65	-1.5	-2.2	-3.1	-3.8	-6.6	-2.0
All	-7.1	-9.5	-10.0	-10.8	-12.3	-8.9

Exemption from asset income taxation

Back

	< 40	40–75	75–125	125–250	> 250	All
25–35	-0.1	-0.1	-0.1	-0.1	0.1	-0.1
35–50	-0.8	-1.0	-1.3	-1.8	-1.9	-1.2
50–65	-3.2	-2.9	-3.3	-4.2	-5.0	-3.5
> 65	-4.7	-7.2	-7.4	-7.4	-7.4	-5.6
All	-2.4	-1.8	-2.1	-2.9	-3.3	-2.4

Homeowner subsidy in the United States

	< 40	40–75	75–125	125–250	> 250	All
25–35	0.3	-6.0	-16.9	-23.2	-26.3	-9.1
35–50	1.9	-6.0	-15.4	-21.6	-21.6	-10.7
50–65	5.0	-6.0	-12.2	-18.5	-21.6	-9.1
> 65	12.9	1.9	-1.3	-12.2	-16.9	6.6
All	8.2	-4.4	-12.2	-20.1	-21.6	-6.0

Own calculation based on Poterba and Sinai (2008)

User Cost in the United States

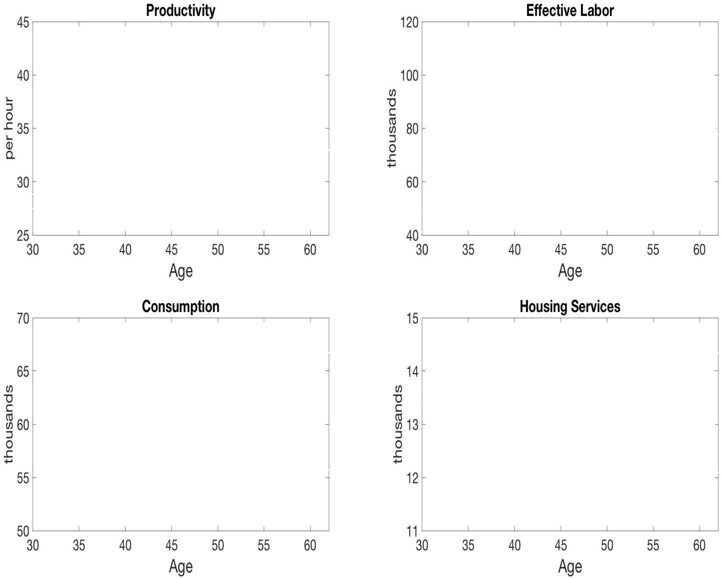
	< 40	40–75	75–125	125–250	> 250	All
25–35	6.4	6.0	5.3	4.9	4.7	5.8
35–50	6.5	6.0	5.4	5.0	5.0	5.7
50–65	6.7	6.0	5.6	5.2	5.0	5.8
> 65	7.2	6.5	6.3	5.6	5.3	6.8
All	6.9	6.4	5.6	5.1	5.0	6.0

Table 2 in Poterba and Sinai (2008)

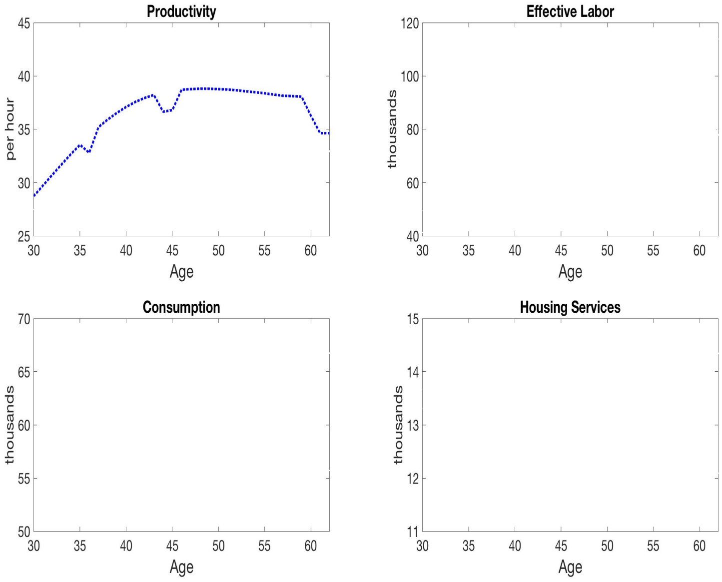
$$p^n = r + \hat{\delta}^H - \pi^H = 6.0 + 2.5 - 2.1 = 6.4$$

Three life-cycle paths

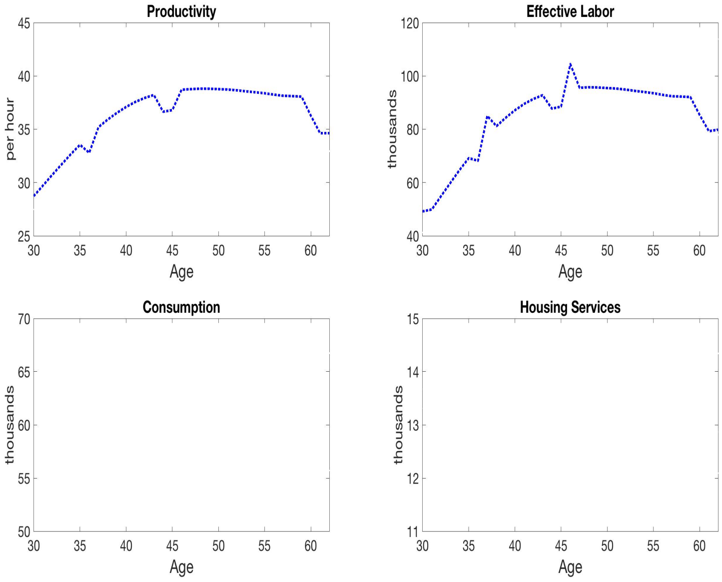
Back



Three life-cycle paths

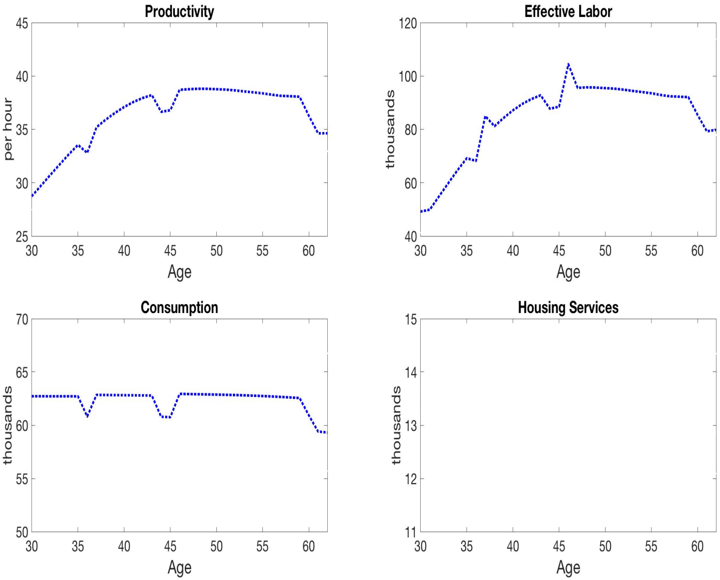


Three life-cycle paths



Three life-cycle paths

Back



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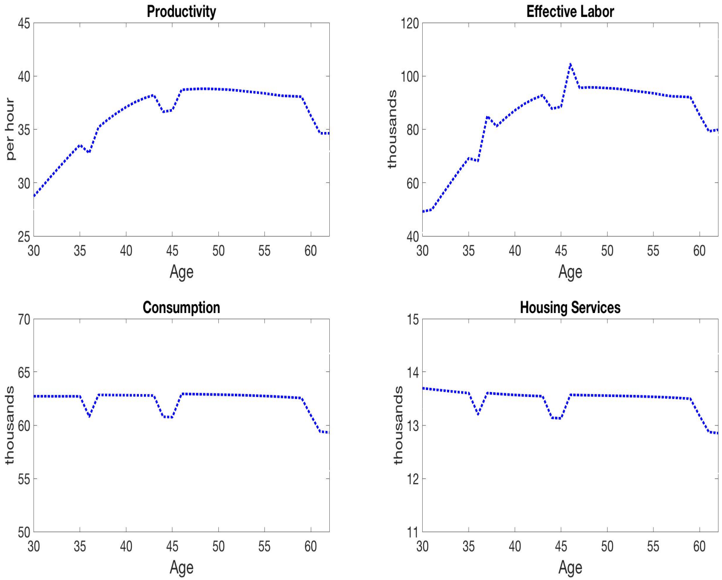
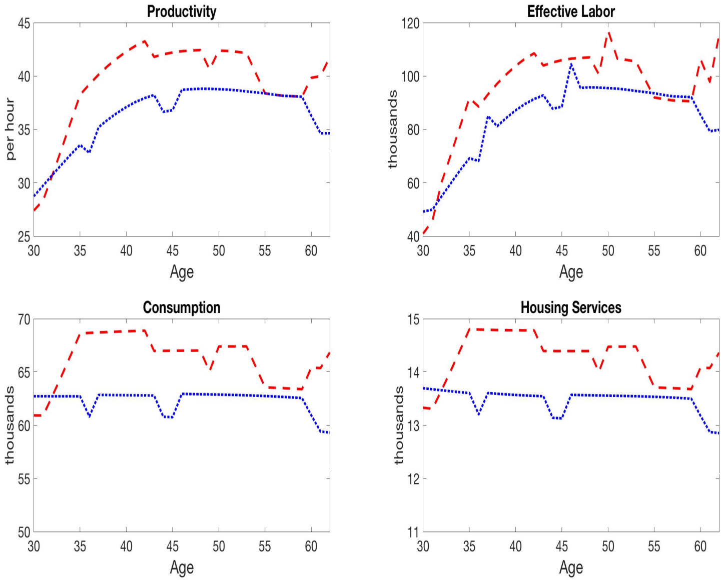


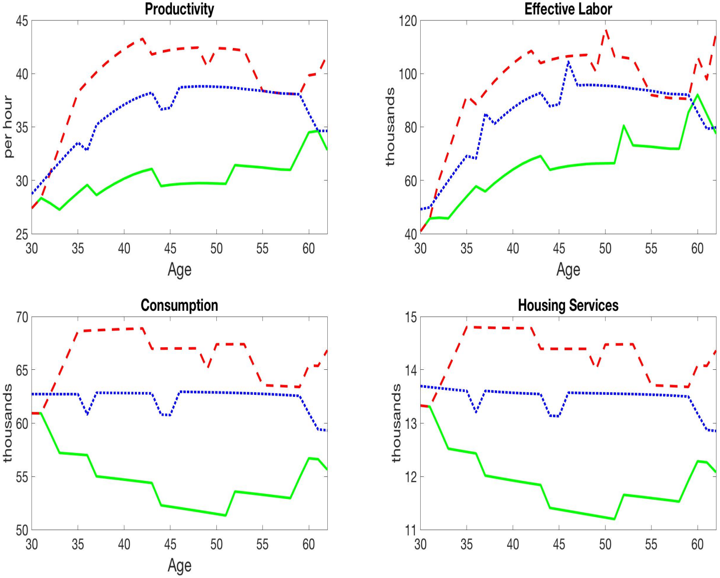
Three life-cycle paths

Back



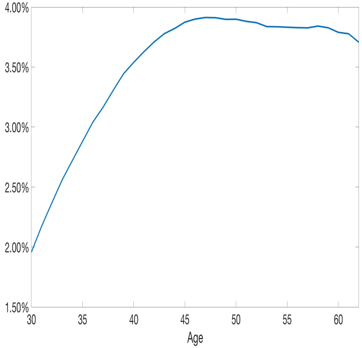
Three life-cycle paths

Back

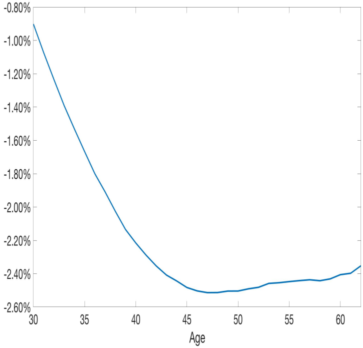


Efficient housing wedge

Back



(a) complements, $\sigma = 2/3$



(b) substitutes, $\sigma = 2$

Netherlands

Small variation in neighborhood house values

Taxatieverslag Woningen

Locatie woning

Straatnaam	Wezeboom
Huisnummer	8
Postcode	3755 WT
Woonplaats	Eemnes
WOZ-objectnummer	31700003060

Waardepeildatum	1 januari 2015	**Toestandspeildatum**	1 januari 2015

Vastgestelde WOZ-waarde	**€ 212.000**	(waardepeildatum 1 januari 2015)
Vorige Vastgestelde WOZ-waarde	€ 208.000	(waardepeildatum 1 januari 2014)
Verandering van de WOZ-waarde	1,92 %	

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Homogeneity in Housing

Back

Rental property value by income, age

Age	Household income (in thousand euro)					
	< 60	60–80	80–120	120–200	> 200	All
25–35	152.5	168.8	188.5	220.9	–	160.1
35–50	158.4	174.8	197.9	251.4	402.3	170.1
50–65	161.1	175.5	191.4	221.3	323.0	172.1
> 65	278.5	213.1	246.0	286.9	477.1	274.2
All	194.2	177.2	192.7	237.8	375.3	197.2

Owner property value by income, age

Data

Age	Household income (in thousand euro)					
	< 60	60–80	80–120	120–200	> 200	All
25–35	167.1	185.1	210.8	256.5	321.6	190.6
35–50	212.7	223.5	255.5	324.9	433.4	255.3
50–65	233.6	245.8	269.4	325.7	425.0	274.4
> 65	255.0	314.0	348.9	395.4	507.2	285.7
All	223.0	229.5	260.0	325.4	431.4	255.4

Owner loan-to-value by income, age

Data

Age	Household income (in thousand euro)					
	< 60	60–80	80–120	120–200	> 200	All
25–35	1.00	1.03	1.04	1.05	1.03	1.03
35–50	0.75	0.75	0.76	0.80	0.84	0.77
50–65	0.42	0.50	0.51	0.52	0.56	0.49
> 65	0.20	0.24	0.29	0.33	0.42	0.22
All	0.56	0.70	0.69	0.69	0.72	0.64

Wedge definitions

Given a history θ^t

- Housing

$$\frac{u_{d,t}(\theta)}{u_{c,t}(\theta)} \equiv p(1+\tau_d(\theta)) + \Phi_1(\theta) + \frac{1}{R}\sum \pi\left(\theta'|\theta\right)\Phi_2(\theta')$$

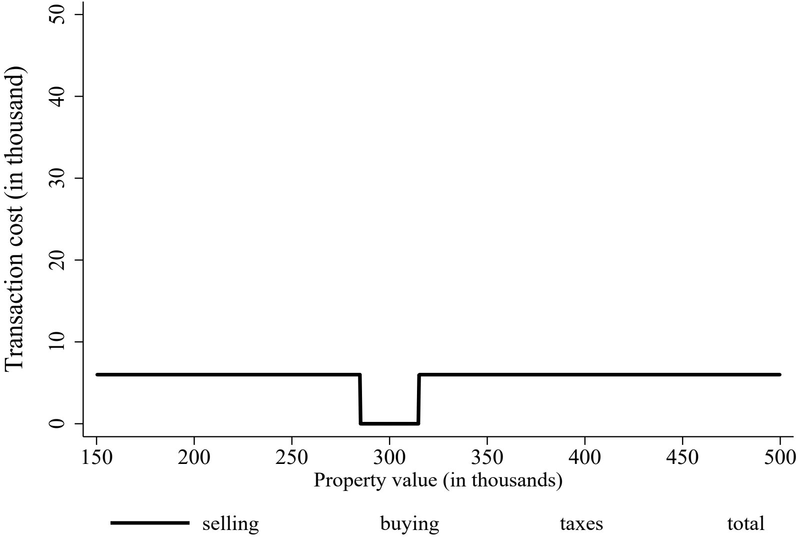
- Labor

$$-\frac{u_{y,t}(\theta)}{u_{c,t}(\theta)} \equiv w(1-\tau_y(\theta))$$

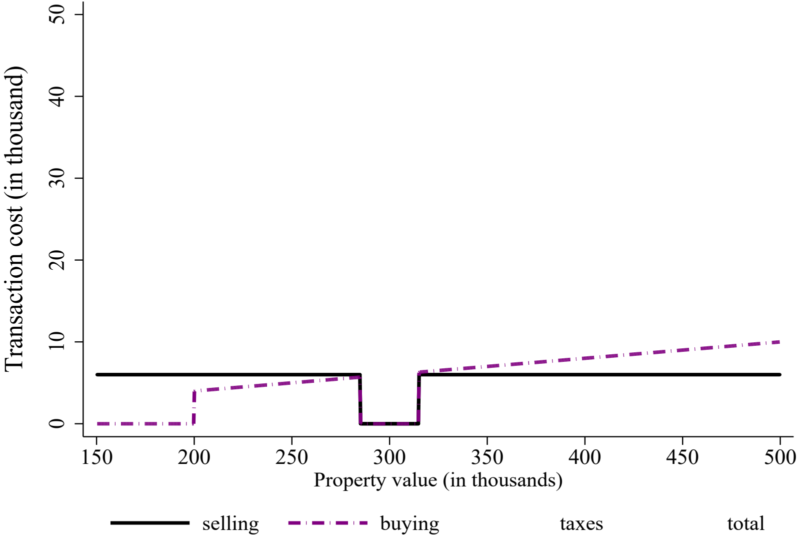
- Savings

$$u_{c,t}(\theta) \equiv \beta R(1-\tau_s(\theta))\sum \pi\left(\theta'|\theta\right) u_{c,t+1}(\theta')$$

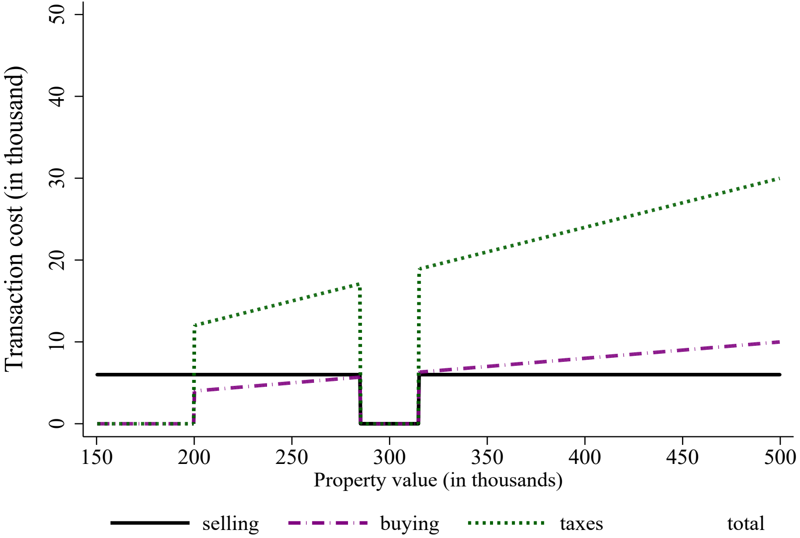
Selling fee


Transaction cost (in thousand)
0
10
20
30
40
50
150
200
250
300
350
400
450
500
Property value (in thousands)
selling
buying
taxes
total

Buying fee


Transaction cost (in thousand)
0
10
20
30
40
50
150
200
250
300
350
400
450
500
Property value (in thousands)
selling
buying
taxes
total

Transaction tax



Transaction cost