

INSURANCE VERSUS MORAL HAZARD IN INCOME-CONTINGENT STUDENT LOAN REPAYMENT

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Disclaimer: The results of these studies are based, in part, on Australian Business Registrar (ABR) data supplied by the Registrar to the ABS under A New Tax System (Australian Business Number) Act 1999 and tax data supplied by the ATO to the ABS under the Taxation Administration Act 1953. These require that such data is only used for the purpose of carrying out functions of the ABS. No individual information collected under the Census and Statistics Act 1905 is provided back to the Registrar or ATO for administrative or regulatory purposes. Any discussion of data limitations or weaknesses is in the context of using the data for statistical purposes, and is not related to the ability of the data to support the ABR or ATO's core operational requirements. Legislative requirements to ensure privacy and secrecy of these data have been followed. Source data are de-identified and so data about specific individuals or firms has not been viewed in conducting this analysis. In accordance with the Census and Statistics Act 1905, results have been treated where necessary to ensure that they are not likely to enable identification of a particular person or organisation.

GOVERNMENT-FINANCED HIGHER EDUCATION

- Governments often provide subsidized financing for higher education
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This Paper: Insurance vs. Moral Hazard

Conditional on ex-ante choices, how does income-contingent repayment affect **labor supply** and welfare?

- ① **Setting:** Australian government's income-contingent student loan program
 - **Variation:** discontinuities in repayment rates + policy change to these rates
 - **Identification:** limited room for selection and ex-ante responses
- ② **Research design:** bunching at discontinuities before and after policy change
 - **Data:** universe of income tax returns + student debt balances

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- ③ **Model**: life cycle model with endogenous labor supply + uninsurable wage risk
 - **Positive**: translate responses into estimates of preference parameters
 - **Normative**: characterize optimal amount and form of income-contingent repayment

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 - **Caveat**: compute optimal contracts taking ex-ante choices as given

MAIN RESULTS

- ① **Empirics:** borrowers reduce labor supply to ↓ income-contingent repayments
 - Larger responses in occupations with more hourly flexibility
 - Responses increase with liquidity constraints and decrease with $P(\text{repayment})$
- ② **Structural estimation:** labor supply elasticity of **0.11** + adjustment frictions
- ③ **Contract design:** moral hazard reduces optimal amount of insurance
 - Fixed repayment → optimal income-contingent loan $\Rightarrow \uparrow 1.3\%$ lifetime consumption
 - Forbearance + fixed repayment does worse because of slower repayment

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Takeaway: income-contingent repayment creates **moral hazard** that affects contract design, but **too small** to justify fixed repayment

RELATED LITERATURE & CONTRIBUTIONS

- ① Financing of human capital Bovenberg-Jacobs 2005, Lochner-Monge-Naranjo 2016, Stantcheva 2017
- ② Empirical effects of student loans
 - \uparrow Debt \Rightarrow \uparrow delinquencies, \downarrow mobility, \downarrow income Di Maggio et al. 2021, \downarrow homeownership Mezza et al. 2020, Δ occupation Luo-Mongey 2019, Δ major Hampole 2022
 - Income-contingent loans \Rightarrow \downarrow delinquencies Herbst 2023, \downarrow defaults Mueller-Yannelis 2019

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Contributions:

- ① Empirical evidence of moral hazard from income-contingent repayment
Britton-Gruber 2020, Herbst et al. 2023
- ② Structural model of labor supply that replicates these responses
 - ✓ Choice of labor supply is dynamic: income-contingent repayment + frictions
- ③ Quantification of how moral hazard affects optimal contract design

RELATED LITERATURE & CONTRIBUTIONS

- ③ Insurance vs. moral hazard in social insurance: UI Gruber 1997, Chetty 2008, Ganong-Noel 2019, HH bankruptcy Dobbie-Song 2015, Indarte 2023, health insurance Einav et al. 2015
- ④ State-contingent securities for households Shiller 2004, Caplin et al. 2007, Mian-Sufi 2014, Hartman-Glaser-Hébert 2020, Greenwald et al. 2021, Campbell et al. 2021, Benetton et al. 2022
- ⑤ Bunching at discontinuities in tax rates Saez 2010, Chetty et al. 2011, Kleven-Waseem 2013
- ⑥ Determinants of labor supply Blundell-MaCurdy 1999, Keane 2011, Chetty 2012, ...

OUTLINE

- 1 Institutional Background and Data
- 2 Labor Supply Responses to Income-Contingent Repayment
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STUDENT LOANS IN AUSTRALIA: HELP

- Australian citizens eligible for government-provided student loans through **HELP**
- **Initial debt** = tuition – government contribution – upfront payment (average $\approx \$20K$ USD)
- Debt grows at CPI net of **income-contingent repayments**:

$$\text{Repayment}_{it} = \text{HELP Rate}_t (\text{HELP Income}_{it}) \times \text{HELP Income}_{it}$$

$$\text{HELP Income}_{it} = \text{Labor Income}_{it} + \text{Capital Income}_{it} - \text{Deductions}_{it}$$

- Repayments continue until remaining debt balance equals zero or death
 - ✗ Cannot be cancelled or discharged in bankruptcy
 - Note: collection done from individual (not household) tax returns

WHY STUDY INCOME-CONTINGENT REPAYMENT IN AUSTRALIA?

- Benefit #1: only one government contract + no private market
 - Only choice is between borrowing and paying upfront; former **heavily** subsidized
 - ✓ Limited scope for **adverse selection** (or selection on moral hazard)
- Benefit #2: loans can only be used for tuition
 - Tuition is government-controlled at public universities (94% of enrollment)
 - ✓ Less room for **ex-ante** moral hazard from changes in borrowing
- Benefit #3: first nationwide provider of income-contingent loans in 1989
 - ✓ Borrowers likely **understand** structure of repayment

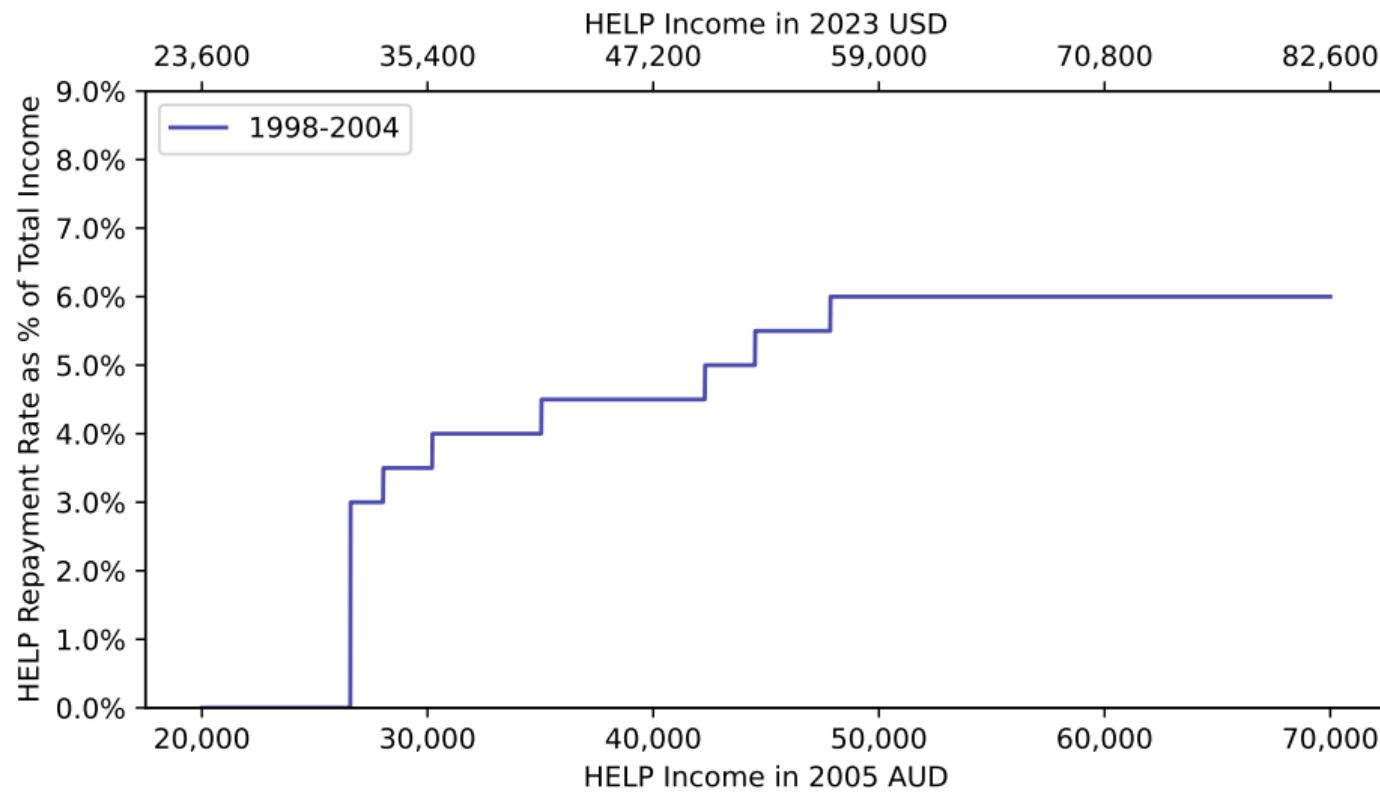
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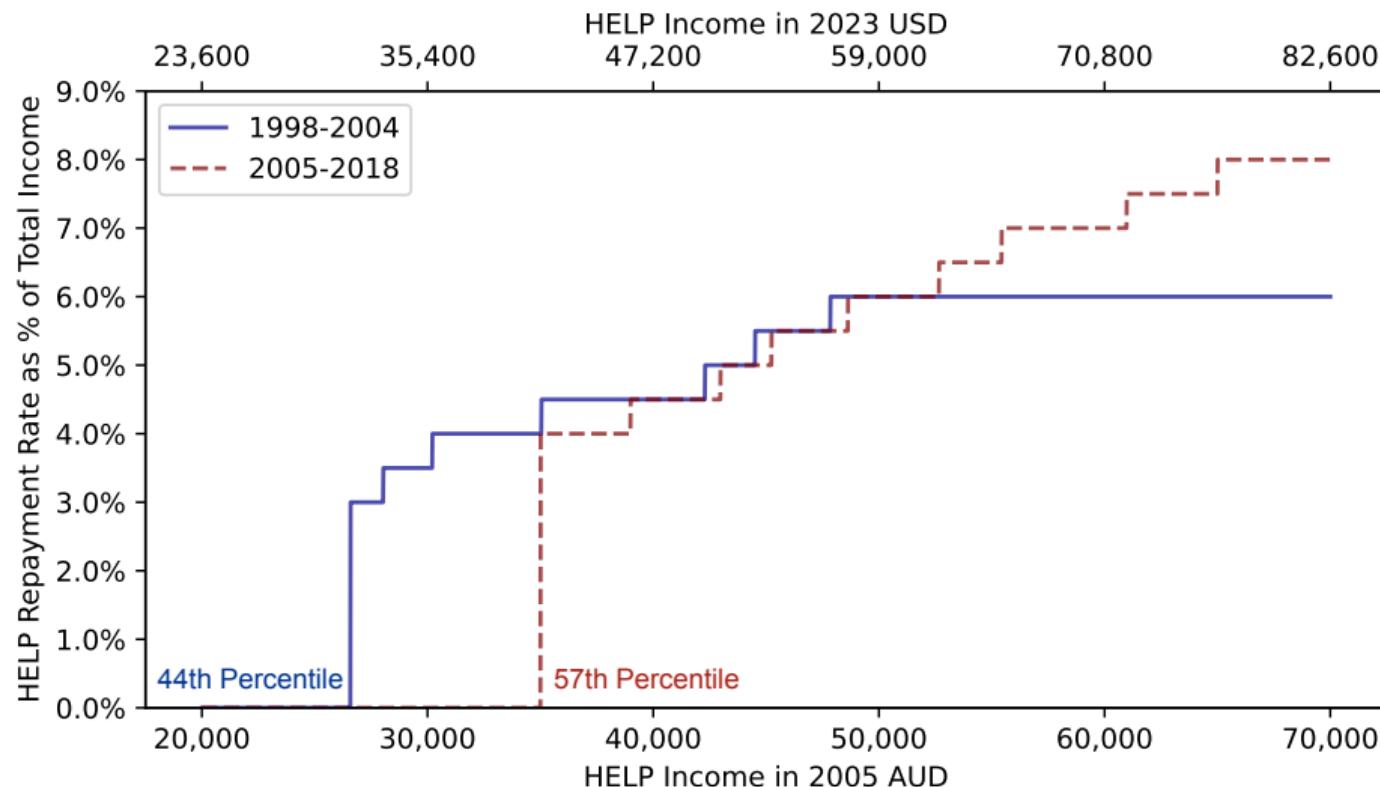
Good setting to identify **labor supply responses** to income-contingent repayment

► Differences from US

IDENTIFYING VARIATION: DISCONTINUITIES IN REPAYMENT RATES

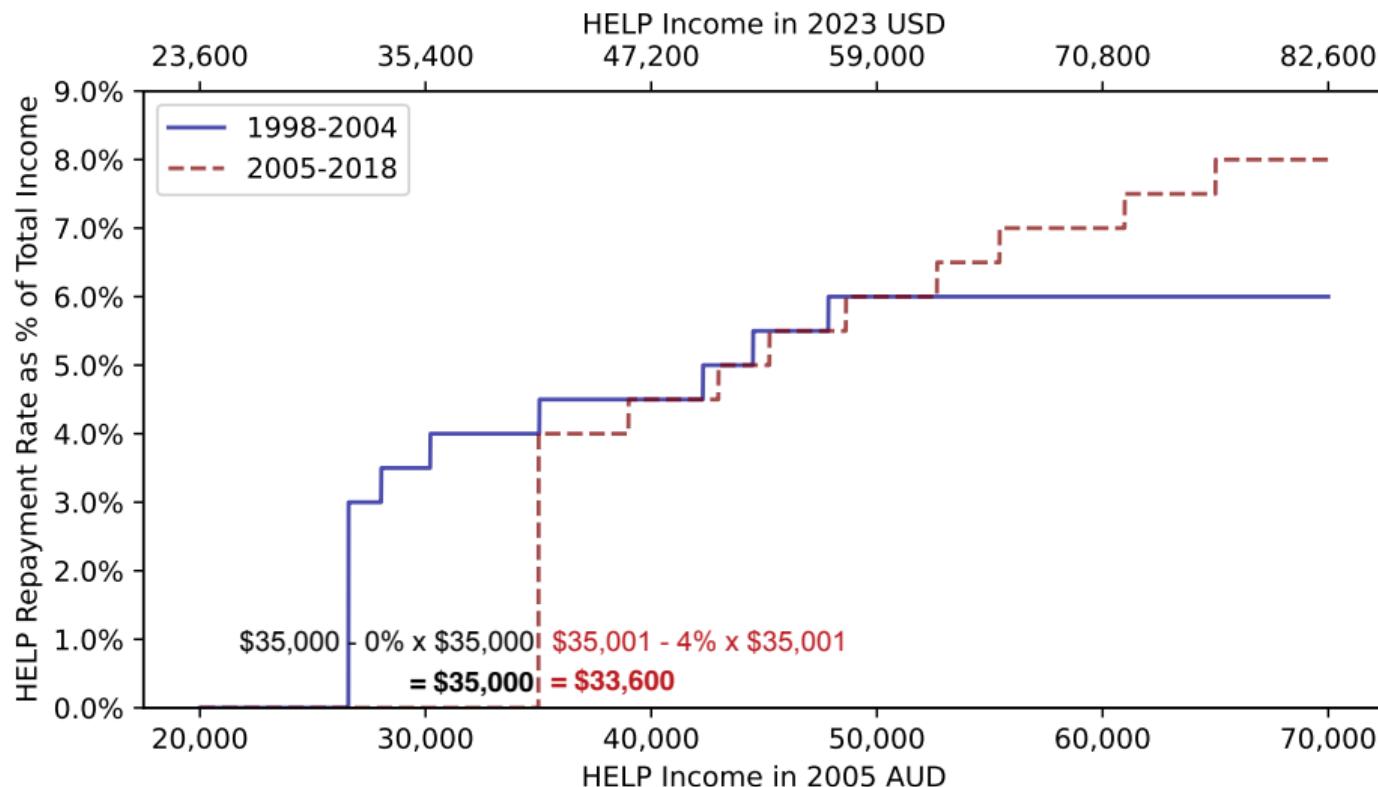


IDENTIFYING VARIATION: POLICY CHANGE TO REPAYMENT RATES



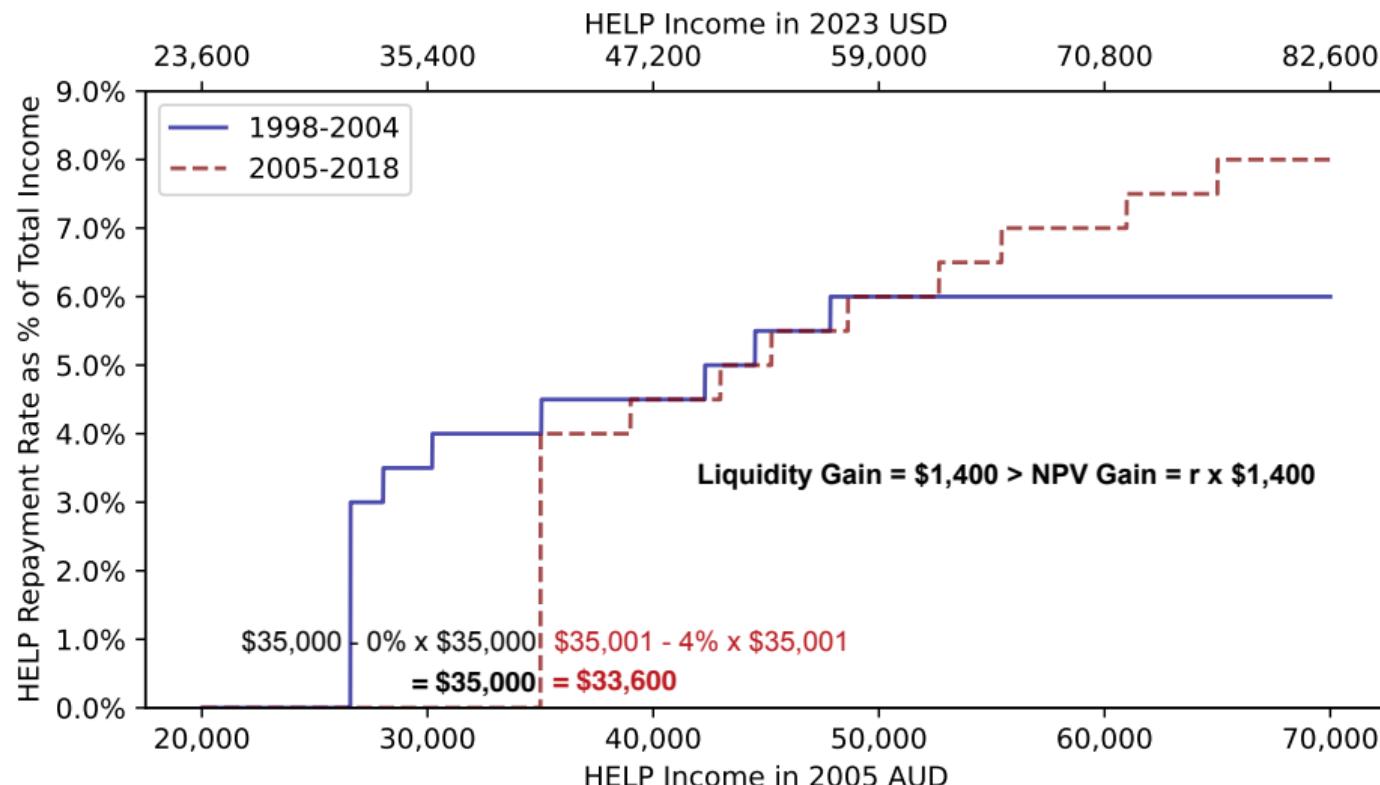
Note: policy change applied to new and existing debtholders

REPAYMENT THRESHOLD INCREASES AVERAGE REPAYMENT RATE



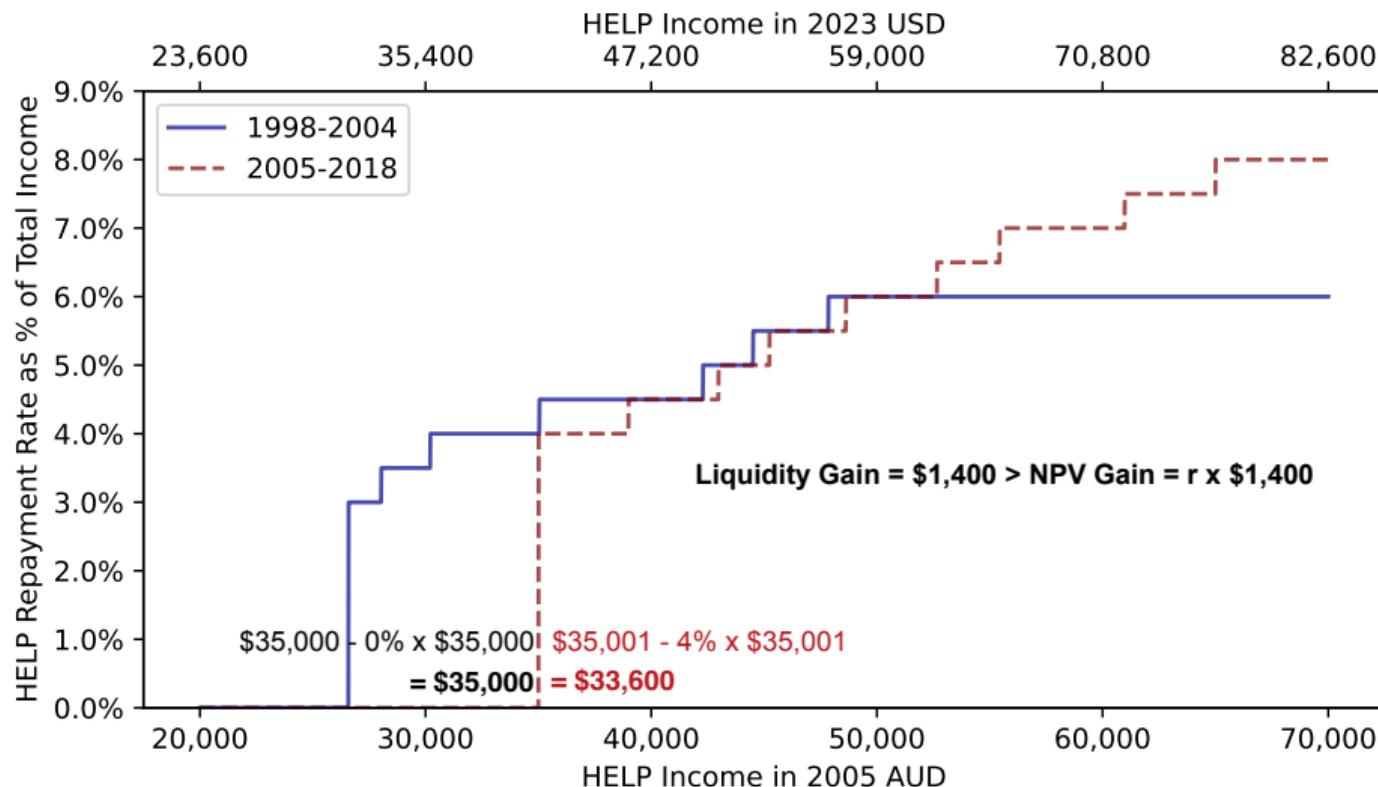
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REPAYMENT THRESHOLD INCREASES LIQUIDITY MORE THAN WEALTH



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Note: policy change applied to new and existing debtholders

► Marginal Rates

► Payments

► News

► Occupations

- ① Universe of individual tax returns from Australian Tax Office (~ US Form 1040)
- ② Administrative HELP data: debt balances and repayments
- ③ 2016 Household Census: self-reported hours and mortgage + rent payments
- ④ Administrative retirement savings data: superannuation balances
- ⑤ HILDA: survey data on hours worked and asset holdings

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Sample: ~ 4 million **unique** debtholders between ages 20-64 from 1991-2018

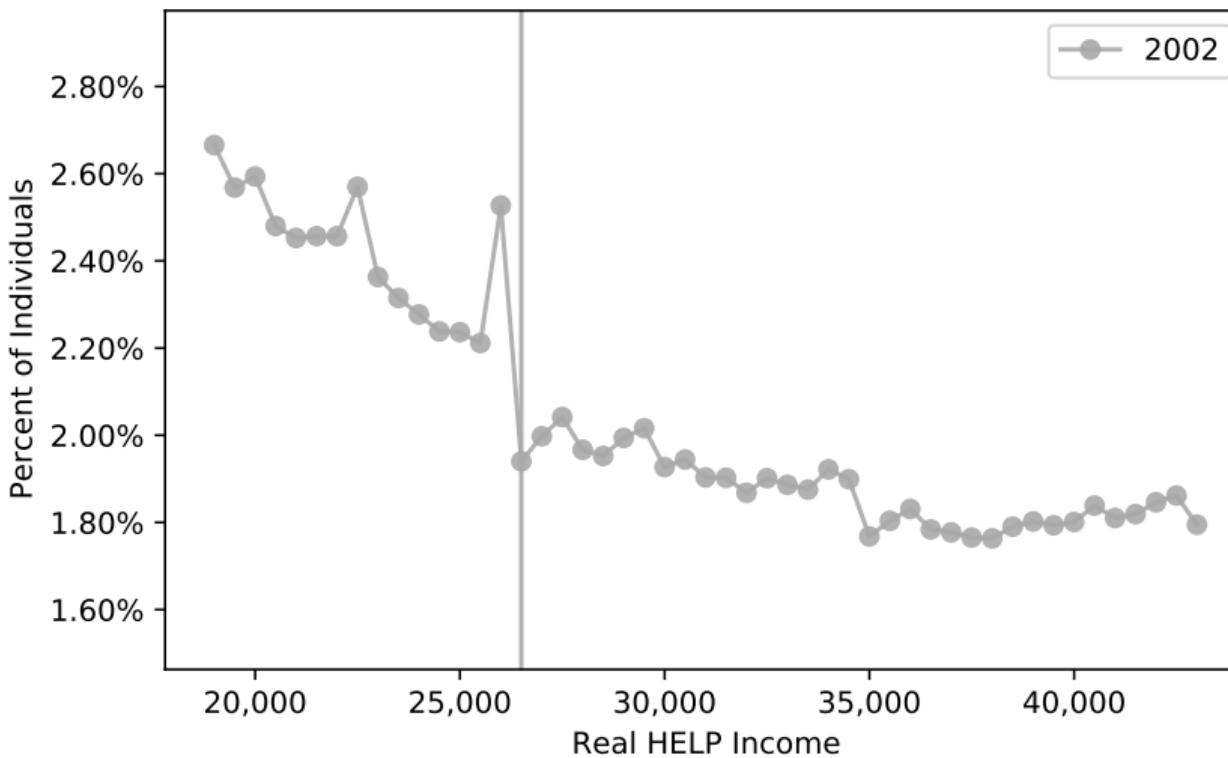
- Mean HELP Income at age 26 = \$34K with 98% from labor income

Limitation: no information about borrowing (e.g., degree, institution) (in progress!)

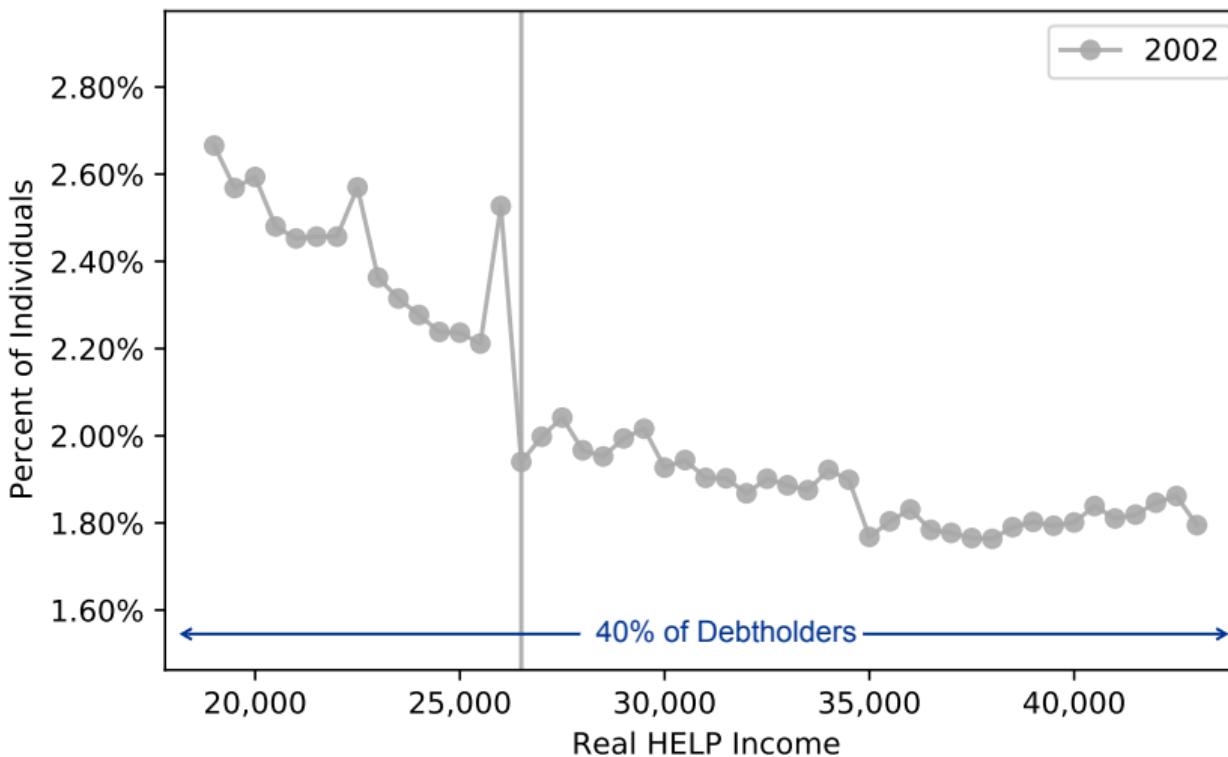
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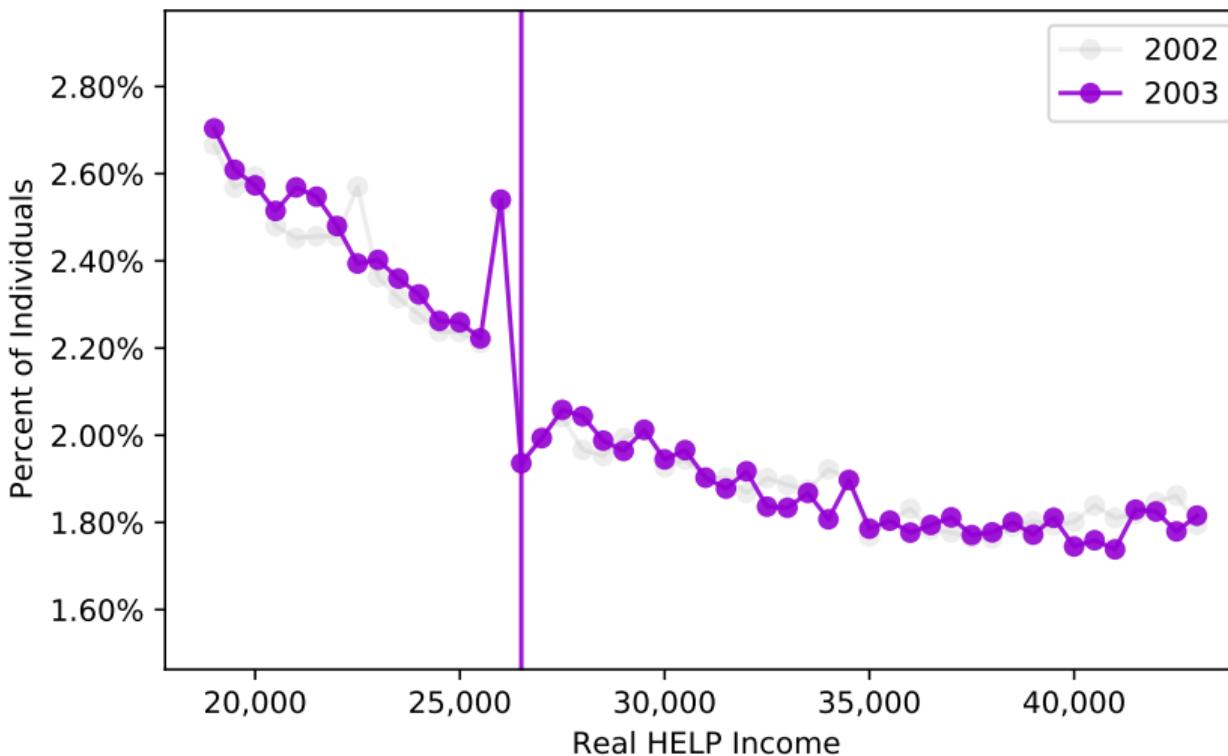
BORROWERS ADJUST INCOME TO REDUCE REPAYMENTS



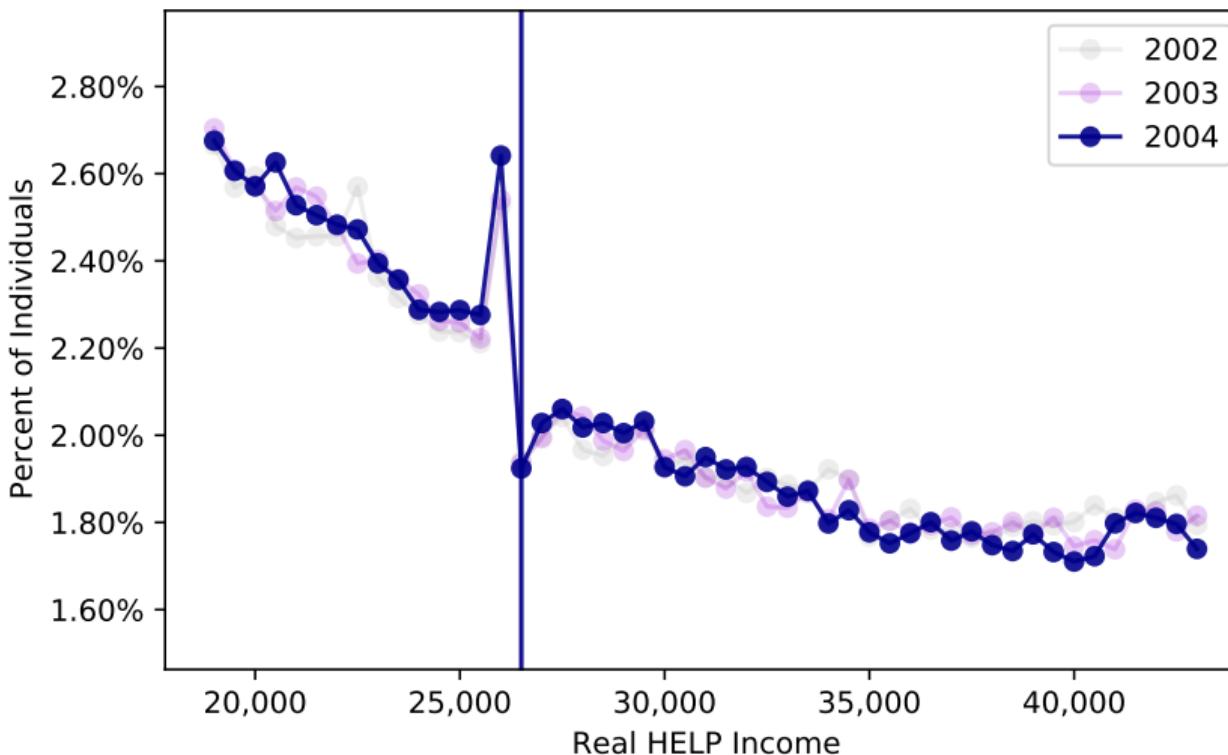
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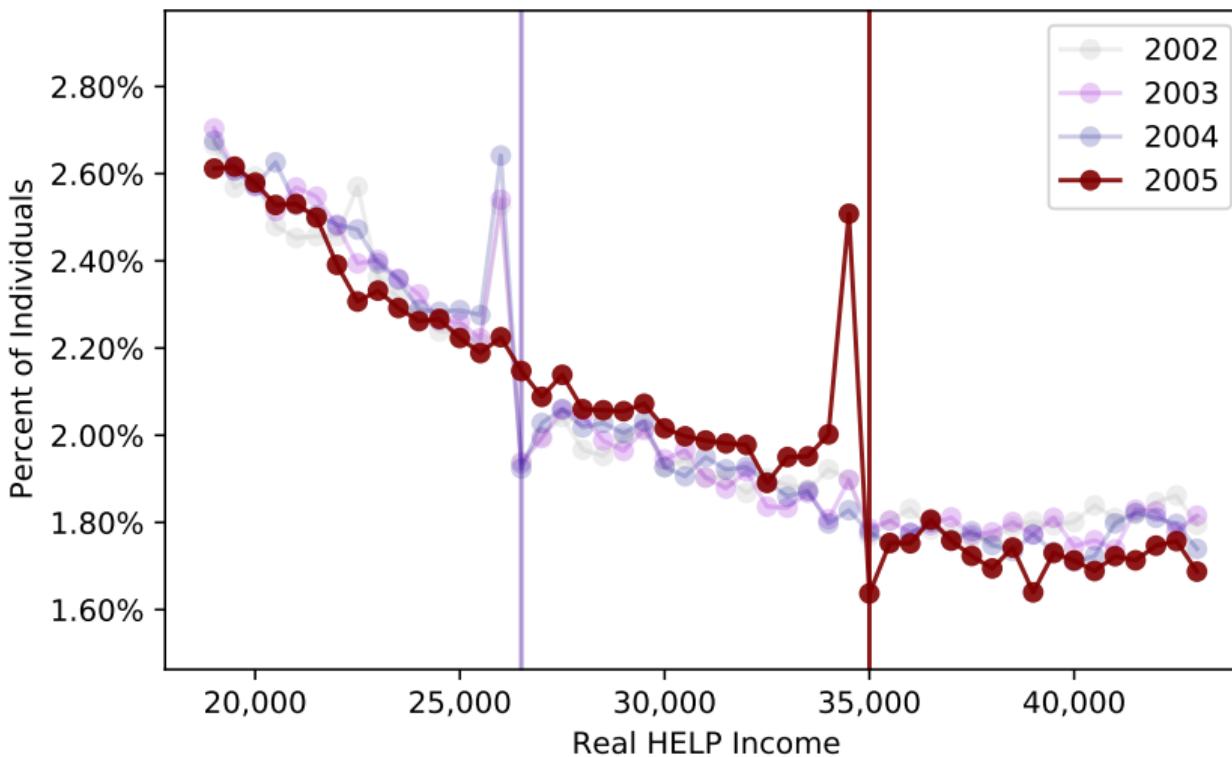
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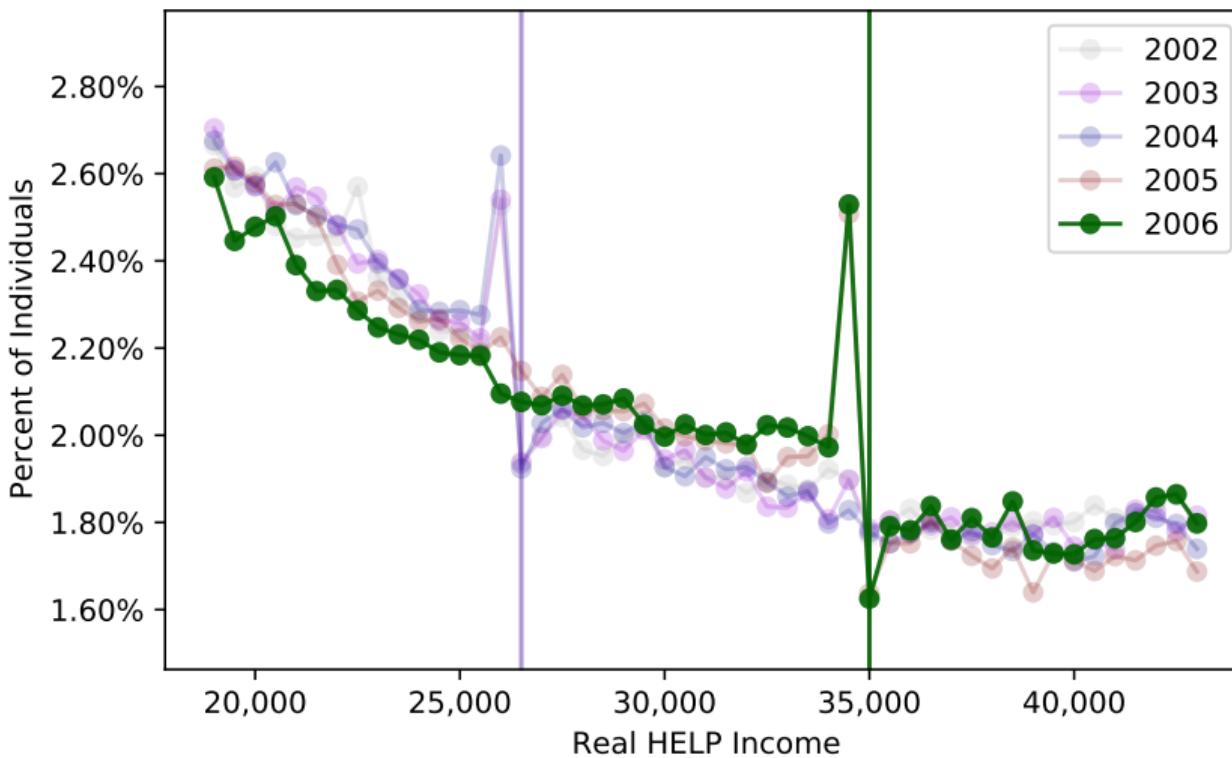
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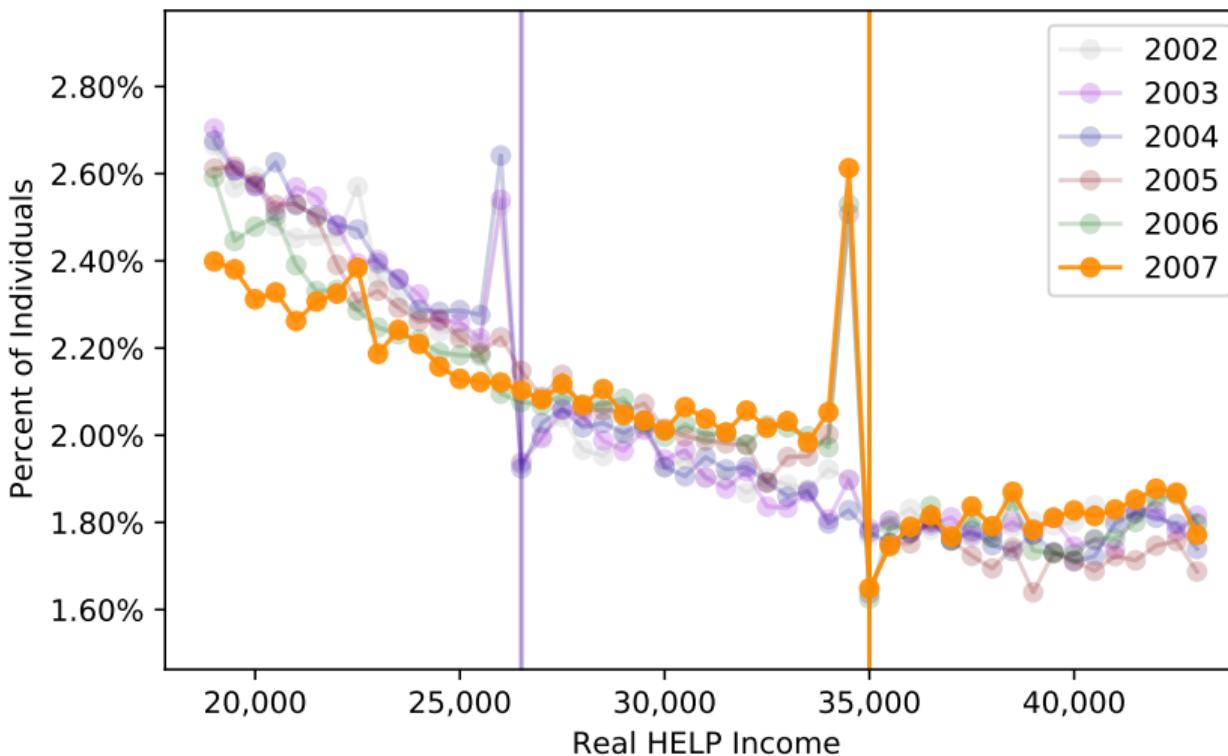
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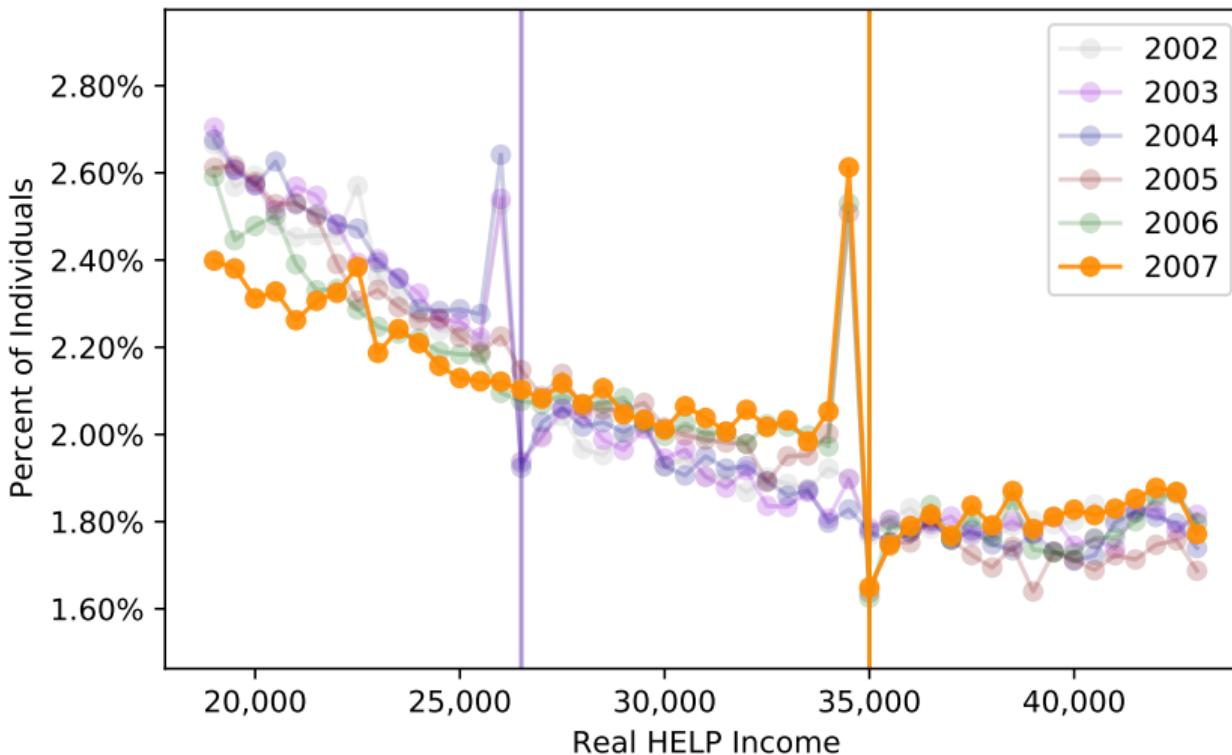
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- Next: does bunching reflect labor supply or evasion?

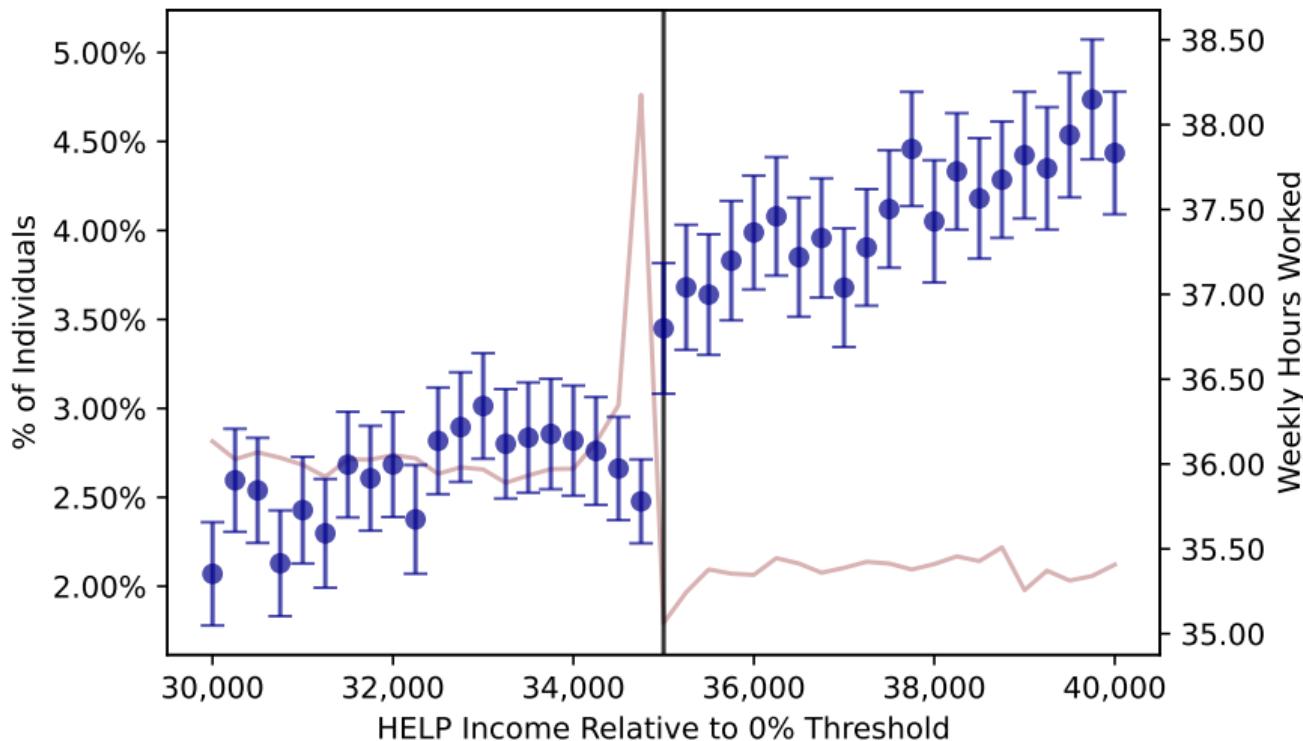
▶ Source

▶ Non-Debt

▶ Labor

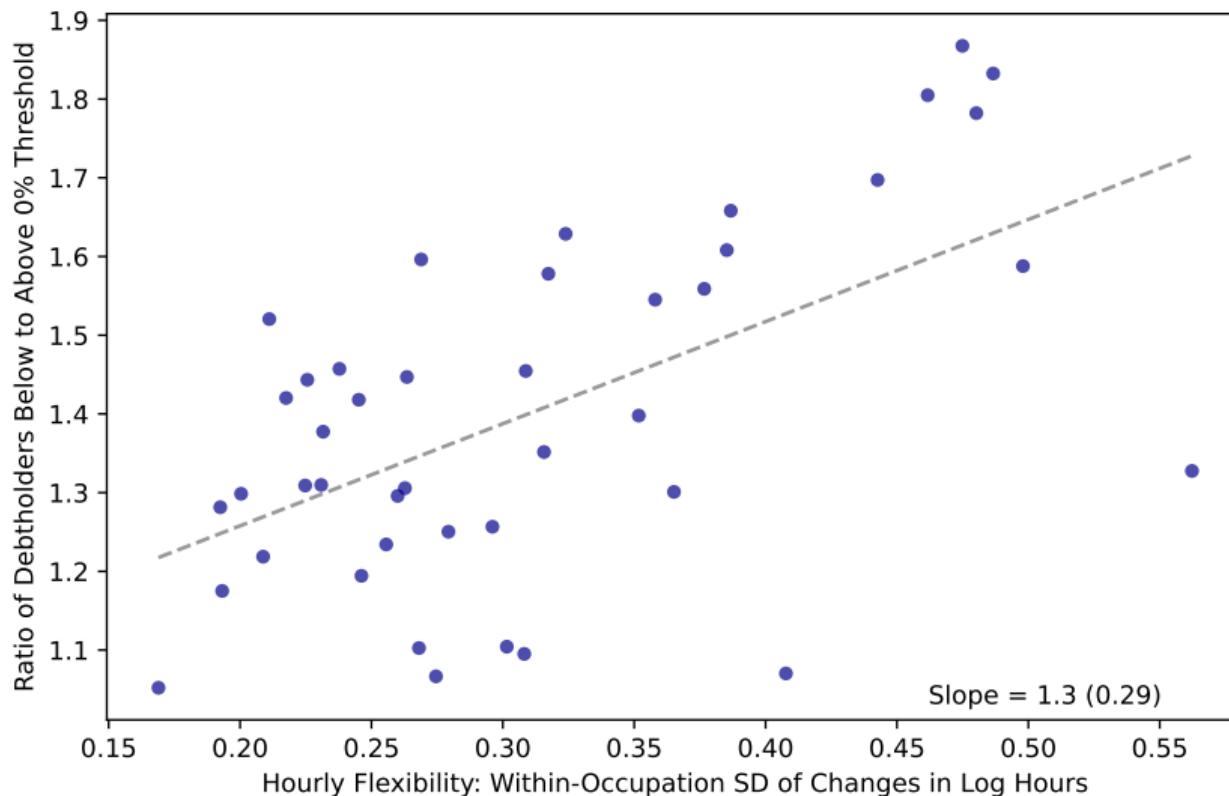
▶ vs Tax

BORROWERS BELOW REPAYMENT THRESHOLD WORK FEWER HOURS



- In 2016, reduction is around **1** hour/week = 1.4 fewer weeks per year

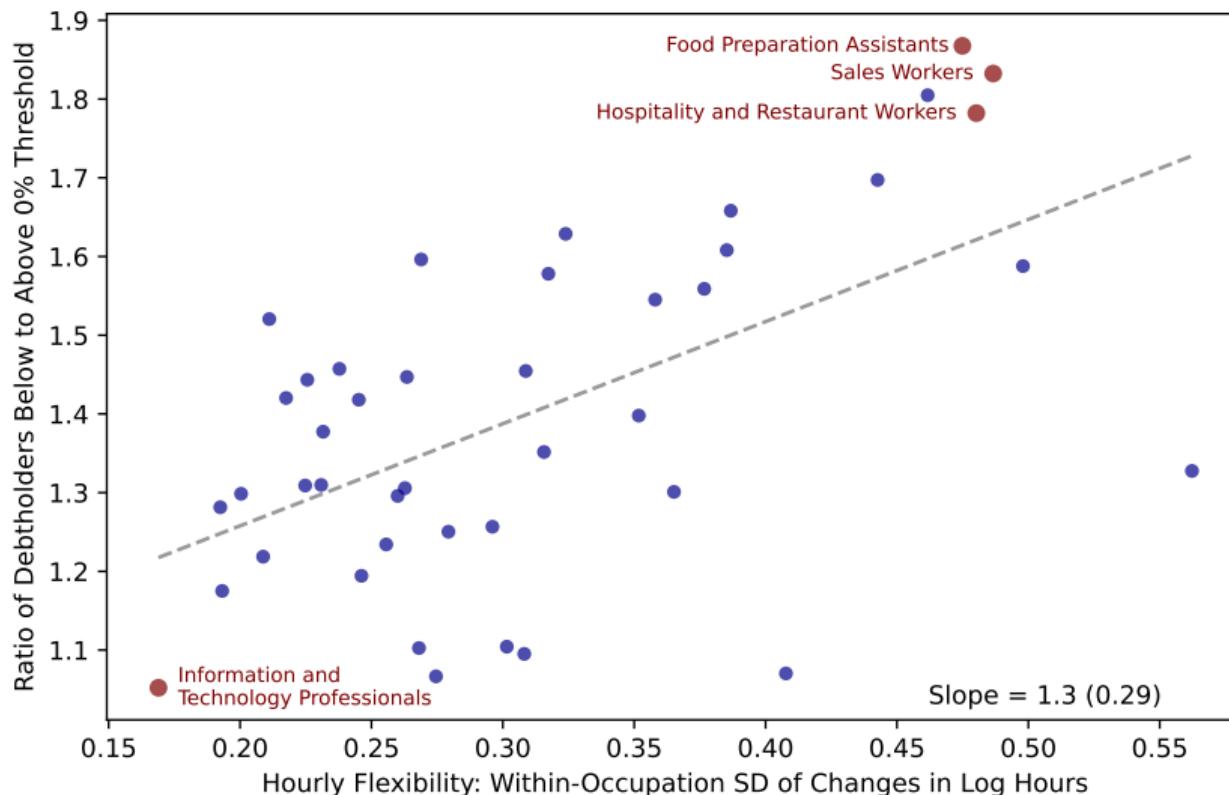
MORE BUNCHING IN OCCUPATIONS WITH GREATER HOURLY FLEXIBILITY



Sample: all wage-earners between 2005-2018

▶ Alt. Measure ▶ Evasion ▶ Table ▶ Profiles ▶ Additional Results

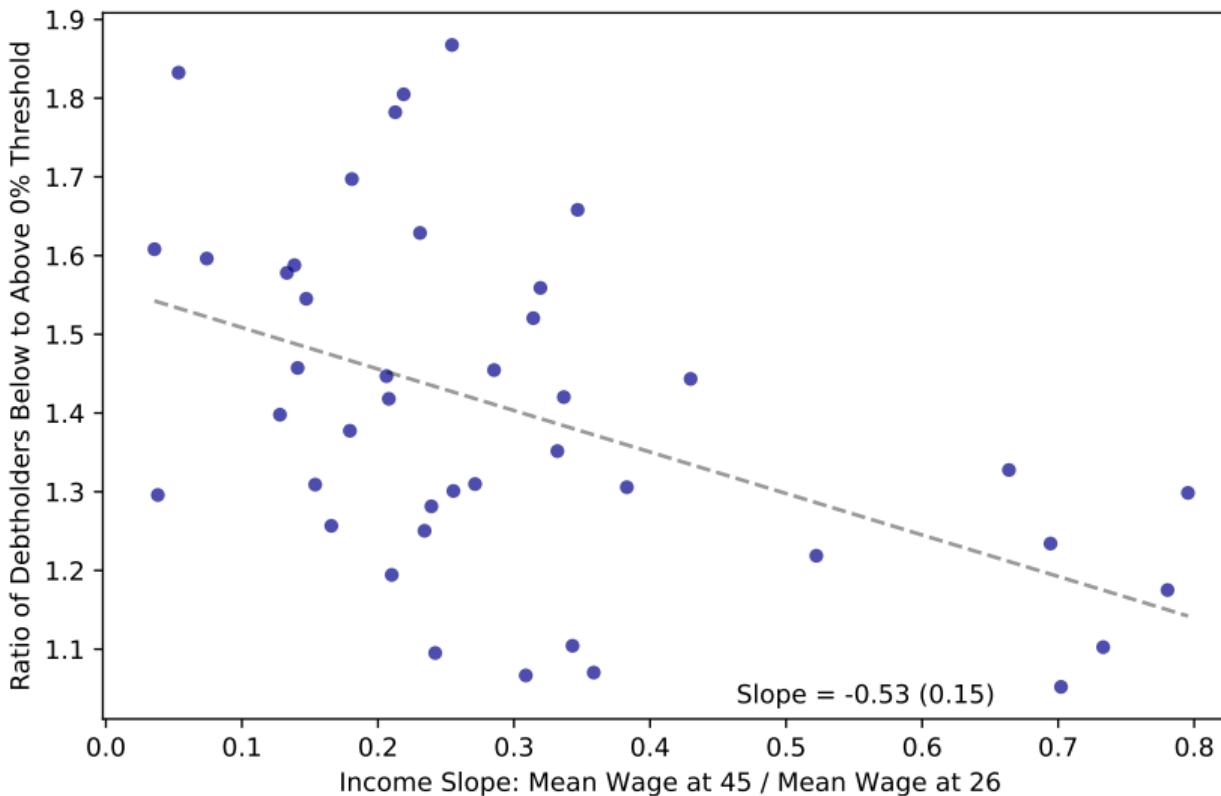
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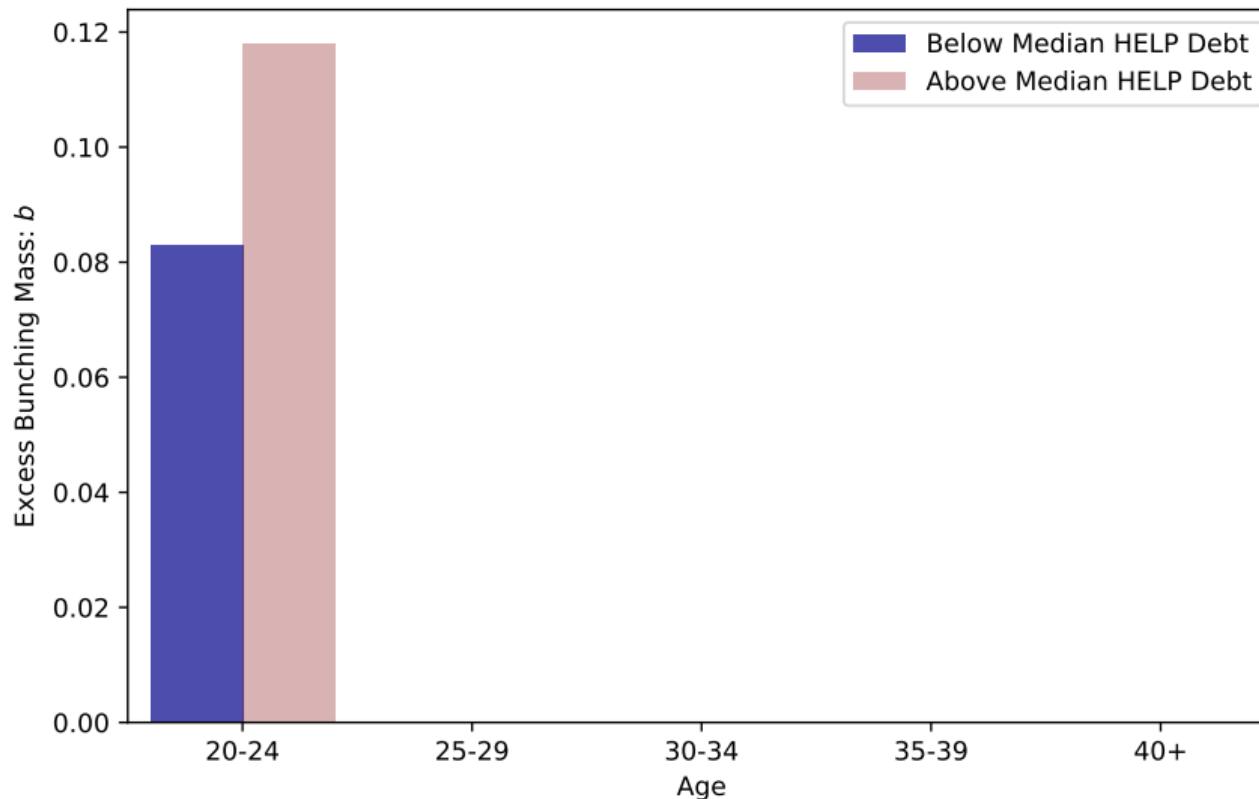
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BUNCHING DECREASES WITH EXPECTED WAGE GROWTH



▶ Table

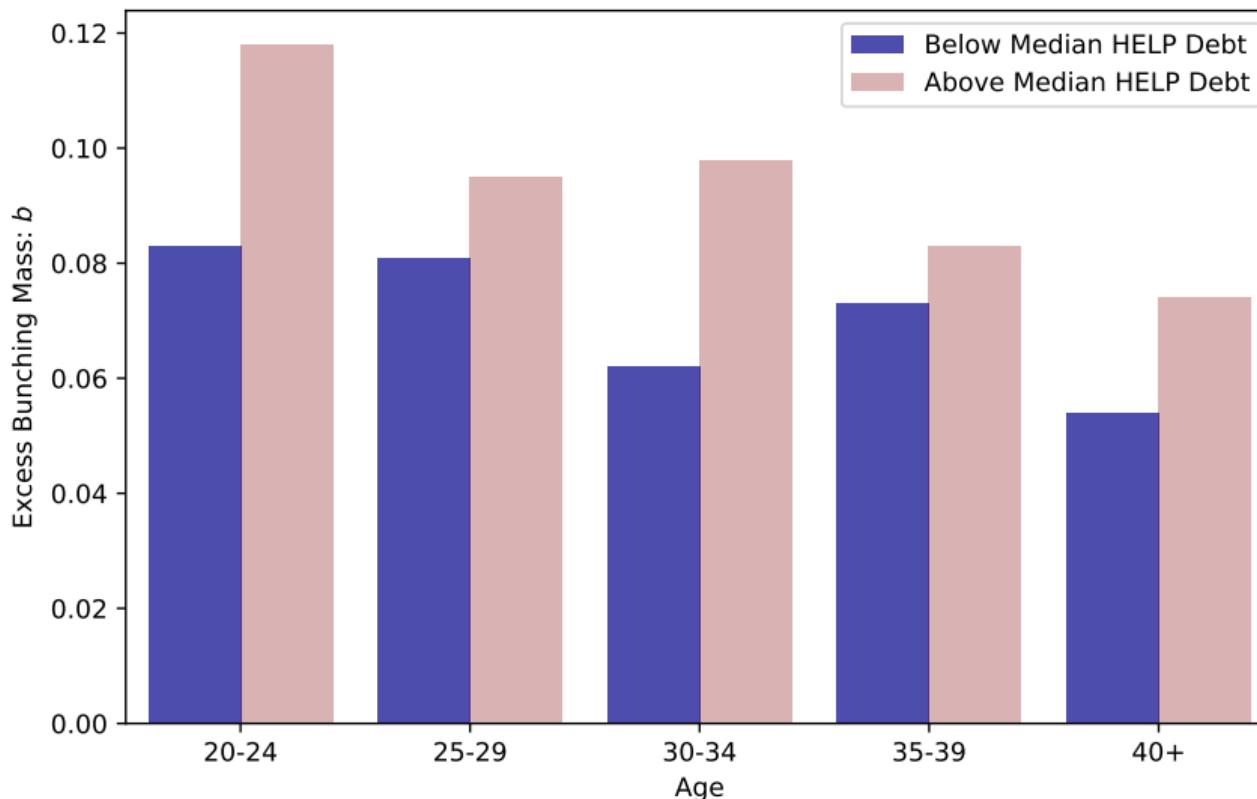
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Note: confidence intervals omitted due to small size

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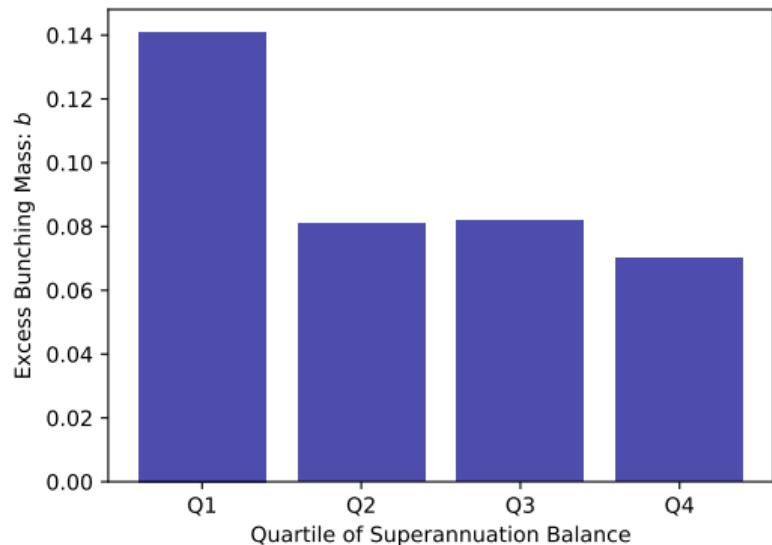
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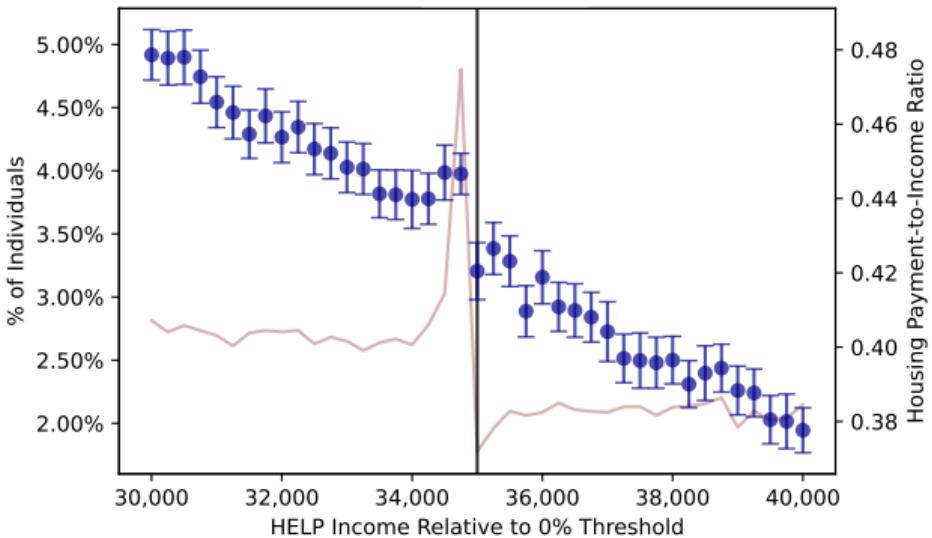
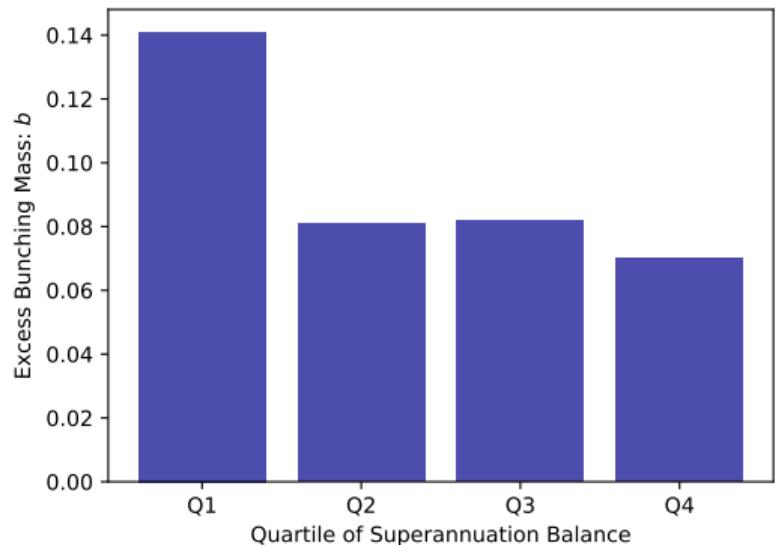
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BUNCHING INCREASES WITH PROXIES FOR LIQUIDITY CONSTRAINTS



► Within Age ► House Prices

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Empirical facts:

► Additional Results

- ① Borrowers reduce income in response to income-contingent repayment
 - Reflects labor supply: “bunchers” work fewer hours and in more flexible occupations
- ② Size of responses depends on
 - **P(repayment)**: increases with debt, decreases with wage growth and peak
 - **Liquidity**: increases with liquidity demands, decreases with retirement wealth
- ③ Limited evidence of future wage reductions from reducing labor supply 

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Questions for model:

- ① How large are these labor supply responses quantitatively?
- ② Do they imply the costs of income-contingent repayment exceed the benefits?

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MODEL DESCRIPTION

OVERVIEW

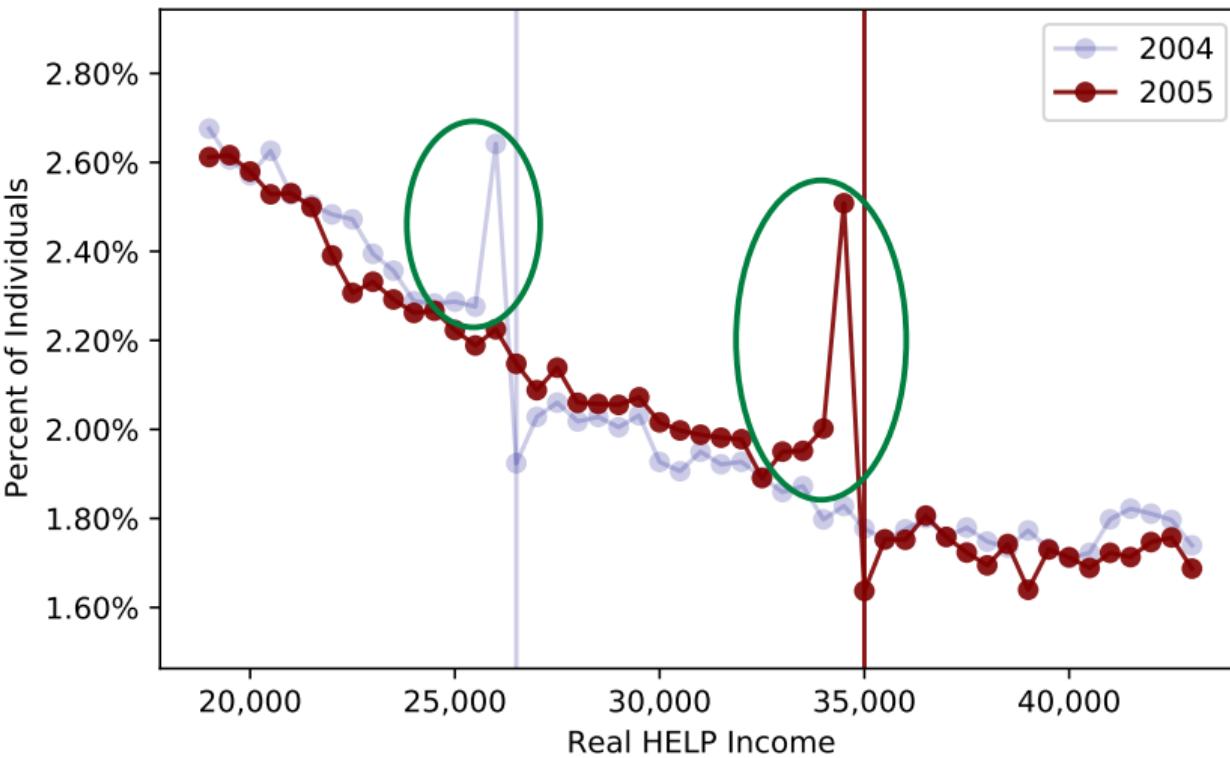
Life cycle model with debt + incomplete markets + endogenous labor supply

- Overlapping generations born at 22 with heterogeneous assets, wage, and debt
- From 22 to 64, individuals choose consumption, c_a , and labor supply, ℓ_a
 - Wage rate subject to idiosyncratic shocks (no aggregate risk, partial equilibrium)
 - Shocks are **uninsurable**: borrowing allowed up to age-dependent limit with interest
- After age 64, individuals retire and choose consumption c_a

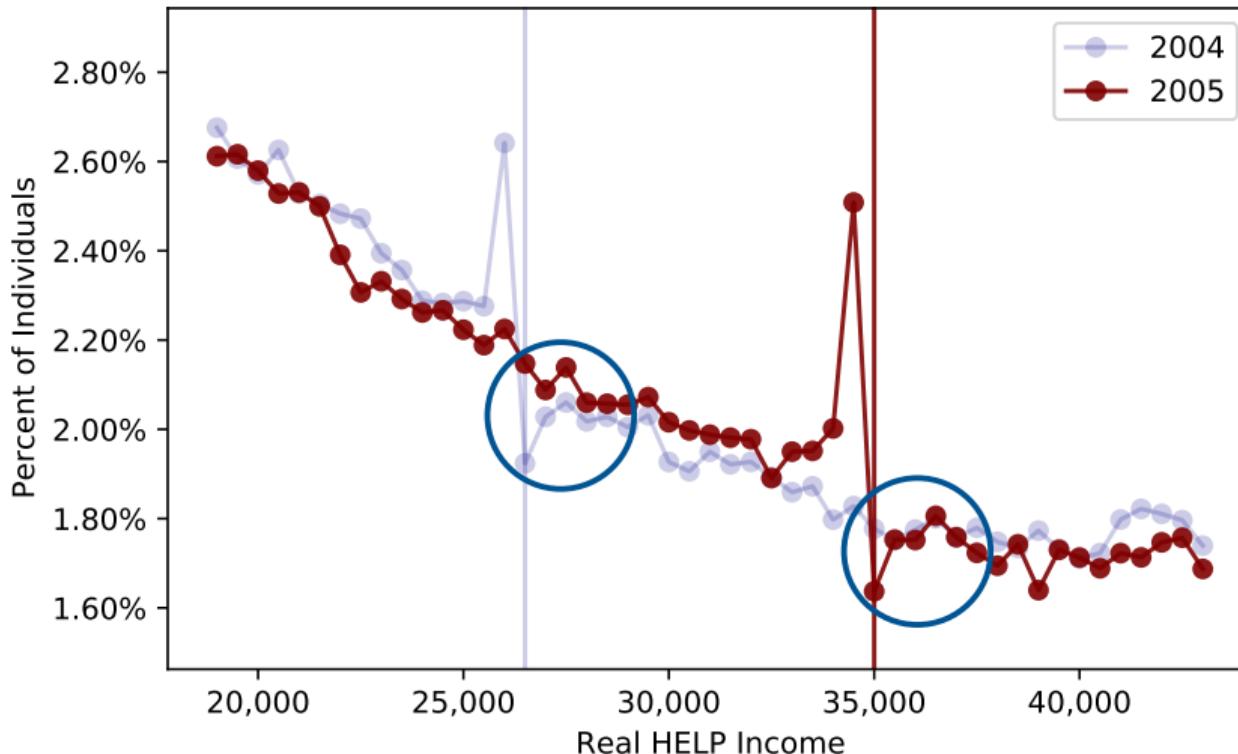
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- **Government**
 - Revenues: progressive income taxes, debt repayments
 - Expenses: means-tested unemployment benefits & retirement pension, initial debt

BUNCHING CONSISTENT WITH POSITIVE LABOR SUPPLY ELASTICITY



MASS ABOVE THRESHOLD INCONSISTENT WITH FRICTIONLESS MODEL



- Moving above to below threshold \Rightarrow more leisure **and** \$1400 more cash-on-hand

- Choice of ℓ_a subject to two **optimization frictions** to give mass above threshold
 - Similar to models of pricing Nakamura-Steinsson 2010 and refinancing Andersen et al. 2020

① Canonical model of **time**-dependent adjustment (Calvo):

- Fraction λ hit by shock and adjust ℓ_a , other $1 - \lambda$ set $\ell_a = \ell_{a-1}$
- E.g., inattention, arrival of opportunities to change hours/jobs

② Canonical model of **state**-dependent adjustment (sS):

- Individuals hit by **Calvo shock** incur utility cost f , if they choose $\ell_a \neq \ell_{a-1}$
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 - Robustness: linear adjustment costs
 - Extension: add learning-by-doing to generate long-run cost of bunching

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) =$$

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$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq \underline{A}_{a+1}, \\ \ell_a}} \underbrace{c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}}}_{\text{utility of consumption} \\ \& \text{disutility of labor}}$$

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$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq A_{a+1}, \\ \ell_a}} c_a - \kappa \underbrace{\frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}}}_{\text{utility of consumption} \\ \& \text{disutility of labor}} - f * \underbrace{\mathbf{1}_{\ell_a \neq \ell_{a-1}}}_{\text{adjustment cost}} + \beta m_a \mathbf{E}_{\mathbf{a}} \underbrace{V_{a+1}(\mathbf{s}_{a+1})}_{\text{continuation value}}$$

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq A_{a+1}, \\ \ell_a}} c_a - \underbrace{\kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}}}_{\text{utility of consumption} \\ \& \text{disutility of labor}} - \underbrace{f * \mathbf{1}_{\ell_a \neq \ell_{a-1}}}_{\text{adjustment cost}} + \beta \left[m_a \mathbf{E}_a \left(\underbrace{V_{a+1}(\mathbf{s}_{a+1})}_{\text{continuation value}}^{1-\gamma} \right) \right]^{\frac{1}{1-\gamma}}$$

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq A_{a+1}, \\ \ell_a}} \left\{ \left[\underbrace{c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}}}_{\text{utility of consumption} \\ \& \text{disutility of labor}} - \underbrace{f * \mathbf{1}_{\ell_a \neq \ell_{a-1}}}_{\text{adjustment cost}} \right]^{1-\sigma} + \beta \left[m_a \mathbf{E}_{\mathbf{a}} \left(\underbrace{V_{a+1}(\mathbf{s}_{a+1})}_{\text{continuation value}}^{1-\gamma} \right) \right]^{\frac{1-\sigma}{1-\gamma}} \right\}^{\frac{1}{1-\sigma}}$$

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$$c_a + A_{a+1} + \underbrace{d(y_a, D_a, t)}_{\text{debt repayment}} + \underbrace{\tau(y_a)}_{\text{taxes + ui}} = \underbrace{y_a}_{\text{labor income}} + \underbrace{A_a R}_{\text{capital income}}$$

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$$y_a = \ell_a w_a, \quad \log w_a = \underbrace{g_a}_{\text{age profile}} + \underbrace{\theta_a}_{\text{permanent income}} + \underbrace{\epsilon_a}_{\text{transitory shock}}$$

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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq \underline{A}_{a+1}, \\ \ell_a}} \left\{ \left[c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}} - f * \mathbf{1}_{\ell_a \neq \ell_{a-1}} \right]^{1-\sigma} + \beta \left[m_a \mathbf{E}_a (V_{a+1}(\mathbf{s}_{a+1})^{1-\gamma}) \right]^{\frac{1-\sigma}{1-\gamma}} \right\}^{\frac{1}{1-\sigma}}$$

$$c_a + A_{a+1} + d(y_a, D_a, \textcolor{blue}{t}) + \tau(y_a) = y_a + A_a R$$

$$y_a = \ell_a w_a, \quad \log w_a = \textcolor{blue}{g}_a + \theta_a + \epsilon_a$$

$$\mathbf{s}_a = (\textcolor{blue}{a} \quad \textcolor{blue}{t} \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- a = age
- t = year to keep track of policy change

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- A_a = savings from previous period
- D_a = debt = $R_d D_{a-1} - d(y_{a-1}, D_{a-1}, t)$

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- θ_a = permanent income = $\rho \theta_{a-1} + \nu_a$ $\nu_a \sim N(0, \sigma_\nu^2)$
- ϵ_a = transitory shock $\sim N(0, \sigma_\epsilon^2)$

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- θ_a = permanent income = $\rho \theta_{a-1} + \nu_a + \alpha \log \ell_{a-1}$ $\nu_a \sim N(0, \sigma_\nu^2)$
- ϵ_a = transitory shock $\sim N(0, \sigma_\epsilon^2)$ Extension: learning-by-doing

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq A_{a+1}, \\ \ell_a}} \left\{ \left[c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}} - f * \mathbf{1}_{\ell_a \neq \ell_{a-1}} \right]^{1-\sigma} + \beta \left[m_a \mathbf{E}_{\mathbf{a}} (V_{a+1}(\mathbf{s}_{a+1})^{1-\gamma}) \right]^{\frac{1-\sigma}{1-\gamma}} \right\}^{\frac{1}{1-\sigma}}$$

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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- ℓ_{a-1} = labor supply from previous period
- ω_a = Calvo shock that determines whether ℓ_a can be adjusted \sim Bernoulli(λ)

OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq A_{a+1}, \\ \ell_a}} \left\{ \left[c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}} - f * \mathbf{1}_{\ell_a \neq \ell_{a-1}} \right]^{1-\sigma} + \beta \left[m_a \mathbf{E}_{\mathbf{a}} (V_{a+1}(\mathbf{s}_{a+1})^{1-\gamma}) \right]^{\frac{1-\sigma}{1-\gamma}} \right\}^{\frac{1}{1-\sigma}}$$

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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- Sources of ex-ante heterogeneity:
 - θ_0 = initial permanent income $\sim N(0, \sigma_i^2)$
 - D_0 = initial debt, A_0 = initial assets

ESTIMATION

- **Interest rates and borrowing:**
 - Interest rate = 1.84%, borrowing rate = CC rate, debt interest rate = 0%
 - Borrowing limit = average CC limit by age
- **Demographics:** cohort birth rates and mortality risk taken from life tables
 - Consumption adjusted for equivalence scale using HH size (Lusardi et al. 2017)
- **Government:** use exact (non-smooth) formulas provided by tax office
- **Initial conditions:** assets and debt distributions taken from data at age 22
- **Baseline RRA and EIS:** $\gamma = \frac{1}{\sigma} = 2.23$ (Choukhmane-de Silva 2023)
 - Welfare analysis: consider alternative values + preference for early resolution

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 - Welfare analysis: consider alternative values + preference for early resolution
- **Learning-by-doing extension:** $\alpha = 0.24$ (median value from Best-Kleven 2013)

SECOND-STAGE SIMULATED METHOD OF MOMENTS

$$\text{Parameters} = \begin{pmatrix} & \\ & \end{pmatrix}$$

- **Estimation** via SMM with 47 moments + 14 parameters
 - Find parameters that minimize % difference between data & model moments
 - **Simulated policy change:** unanticipated change in HELP formula at $t = 2005$

SECOND-STAGE SIMULATED METHOD OF MOMENTS: IDENTIFICATION

$$\text{Parameters} = \left(\begin{array}{c} \overbrace{\phi \ f \ \lambda}^{\text{labor supply}} \\ \end{array} \right)$$

- **Labor supply elasticity:** identified by bunching below repayment threshold
- **Frictions:** identified by mass above repayment threshold

SECOND-STAGE SIMULATED METHOD OF MOMENTS: IDENTIFICATION

$$\text{Parameters} = \begin{pmatrix} \text{labor supply} \\ \phi \ f \ \lambda \end{pmatrix}$$

- **Labor supply elasticity:** identified by bunching below repayment threshold
- **Frictions:** identified by mass above repayment threshold
- Separate identification of frictions
 - **Intuition:** with $f = 0$, decision to bunch depends on Calvo shock not incentives
 - Moments: heterogeneity in bunching with **debt**, bunching at **0.5%** threshold

SECOND-STAGE SIMULATED METHOD OF MOMENTS: IDENTIFICATION

$$\text{Parameters} = \left(\underbrace{\phi, f, \lambda}_{\text{preferences}} \quad \underbrace{\kappa, \beta}_{\text{labor supply}} \quad \underbrace{\delta_0, \delta_1, \delta_2}_{\text{wage profile}} \quad \underbrace{\delta_0^E, \delta_1^E}_{\text{wage profile}} \quad \underbrace{\rho, \sigma_\nu, \sigma_\epsilon, \sigma_i}_{\text{wage risk}} \right)$$

- **Labor supply elasticity**: identified by bunching below repayment threshold
- **Frictions**: identified by mass above repayment threshold
- Separate identification of **frictions**
 - **Intuition**: with $f = 0$, decision to bunch depends on Calvo shock not incentives
 - Moments: heterogeneity in bunching with **debt**, bunching at **0.5%** threshold
- Note: wage profile & risk cannot be estimated separately in first-stage

▶ Other Parameters

▶ Elasticities

▶ SMM Objective

ESTIMATION RESULTS

| Parameter | Estimation | |
|--|-------------------|----------|
| | | Baseline |
| Labor supply elasticity | ϕ | 0.114 |
| Fixed adjustment cost | f | \$377 |
| Calvo parameter | λ | 0.183 |
| Time discount factor | β | 0.973 |
| Labor supply scaling parameter | κ | 0.560 |
| Wage profile parameters | δ_0 | 8.922 |
| | δ_1 | 0.073 |
| | δ_2 | -0.001 |
| | δ_0^E | -0.487 |
| | δ_1^E | 0.020 |
| Persistence of permanent shock | ρ | 0.930 |
| Standard deviation of permanent shock | σ_ν | 0.236 |
| Standard deviation of transitory shock | σ_ϵ | 0.130 |
| Standard deviation of individual FE | σ_i | 0.599 |

► Comparison with Literature

► All Results with SE

ESTIMATION RESULTS

| Parameter | | Estimation | |
|--|-------------------|------------|--------------|
| | | Baseline | No Frictions |
| Labor supply elasticity | ϕ | 0.114 | 0.005 |
| Fixed adjustment cost | f | \$377 | . |
| Calvo parameter | λ | 0.183 | . |
| Time discount factor | β | 0.973 | 0.996 |
| Labor supply scaling parameter | κ | 0.560 | 0.030 |
| Wage profile parameters | δ_0 | 8.922 | 9.862 |
| | δ_1 | 0.073 | 0.111 |
| | δ_2 | -0.001 | -0.002 |
| | δ_0^E | -0.487 | -0.294 |
| | δ_1^E | 0.020 | 0.032 |
| Persistence of permanent shock | ρ | 0.930 | 0.914 |
| Standard deviation of permanent shock | σ_ν | 0.236 | 0.076 |
| Standard deviation of transitory shock | σ_ϵ | 0.130 | 0.504 |
| Standard deviation of individual FE | σ_i | 0.599 | 0.101 |

► Comparison with Literature

► All Results with SE

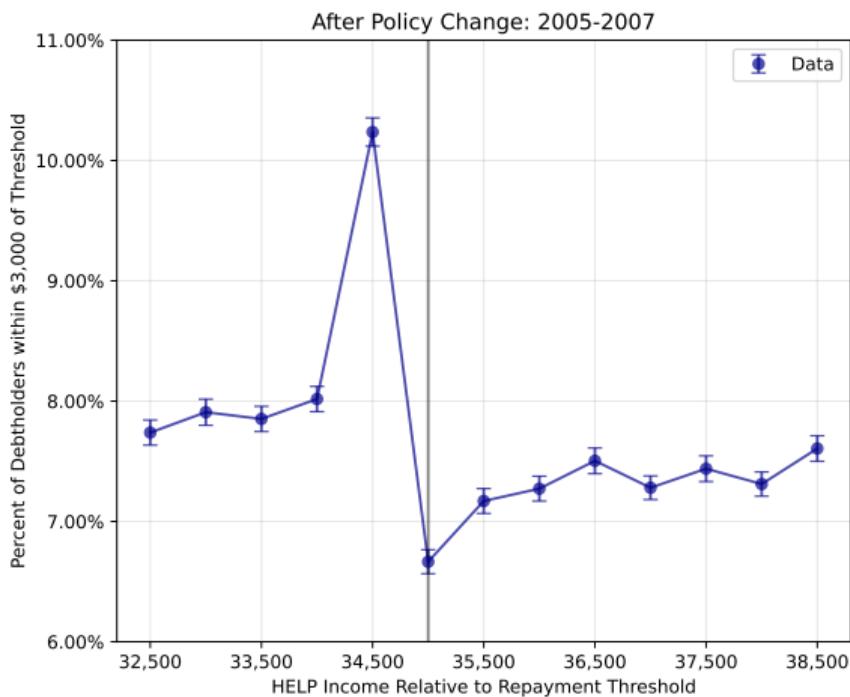
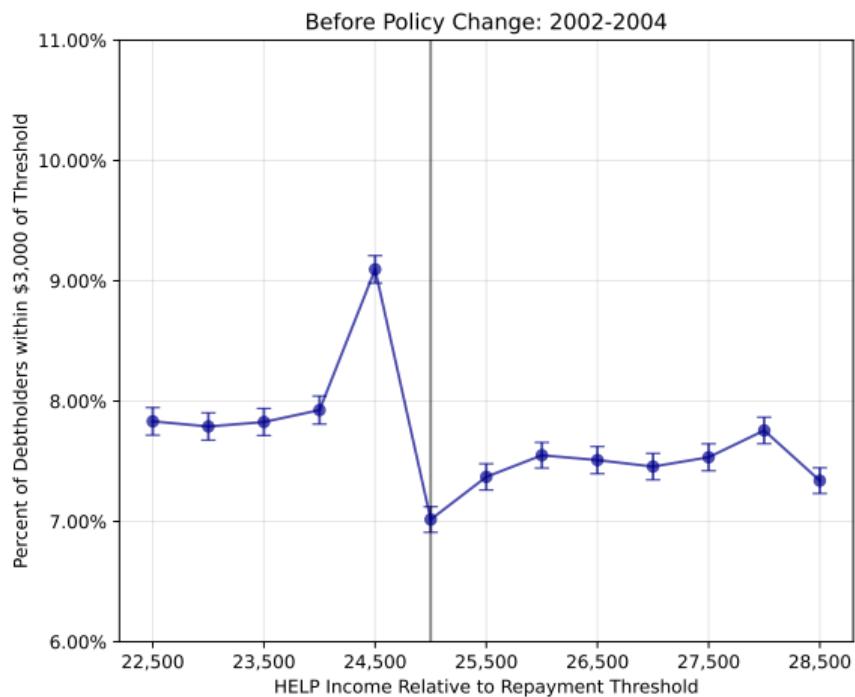
ESTIMATION RESULTS

| Parameter | | Estimation | | |
|--|-------------------|------------|--------------|--------|
| | | Baseline | No Frictions | LBD |
| Labor supply elasticity | ϕ | 0.114 | 0.005 | 0.082 |
| Fixed adjustment cost | f | \$377 | . | \$762 |
| Calvo parameter | λ | 0.183 | . | 0.346 |
| Time discount factor | β | 0.973 | 0.996 | 0.951 |
| Labor supply scaling parameter | κ | 0.560 | 0.030 | 1.242 |
| Wage profile parameters | δ_0 | 8.922 | 9.862 | 9.197 |
| | δ_1 | 0.073 | 0.111 | 0.070 |
| | δ_2 | -0.001 | -0.002 | -0.001 |
| | δ_0^E | -0.487 | -0.294 | -0.480 |
| | δ_1^E | 0.020 | 0.032 | 0.018 |
| Persistence of permanent shock | ρ | 0.930 | 0.914 | 0.889 |
| Standard deviation of permanent shock | σ_ν | 0.236 | 0.076 | 0.288 |
| Standard deviation of transitory shock | σ_ϵ | 0.130 | 0.504 | 0.064 |
| Standard deviation of individual FE | σ_i | 0.599 | 0.101 | 0.625 |

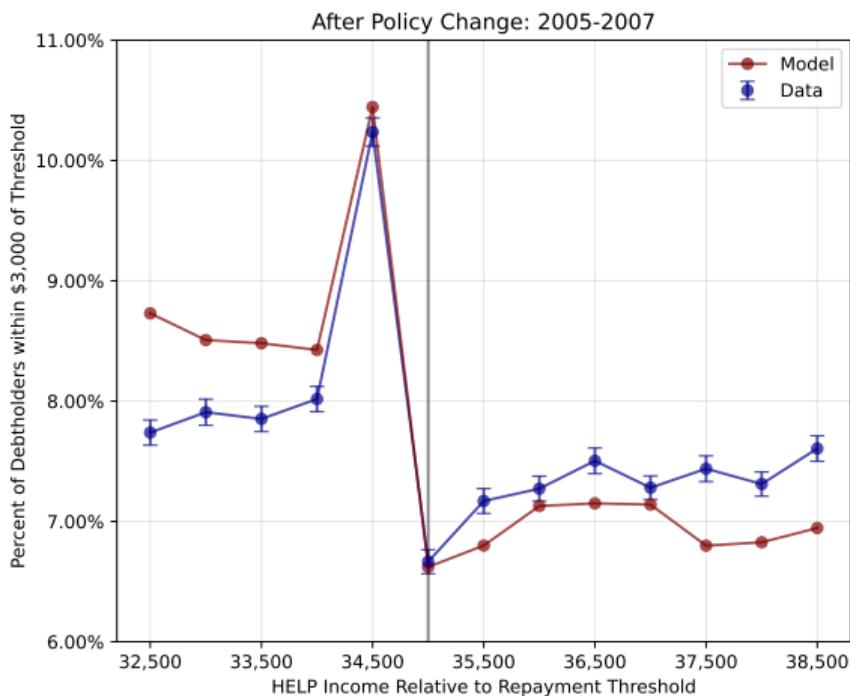
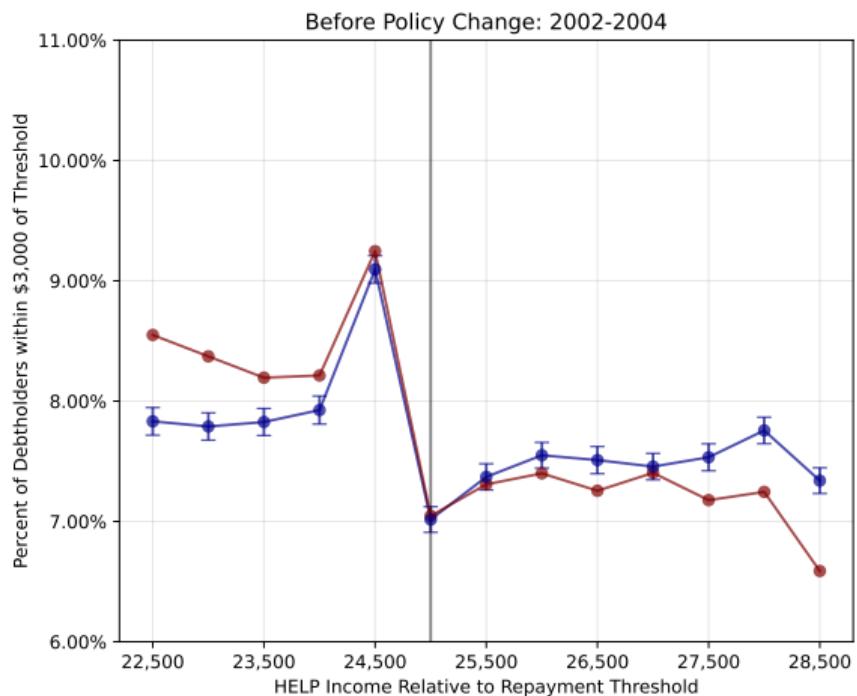
► Comparison with Literature

► All Results with SE

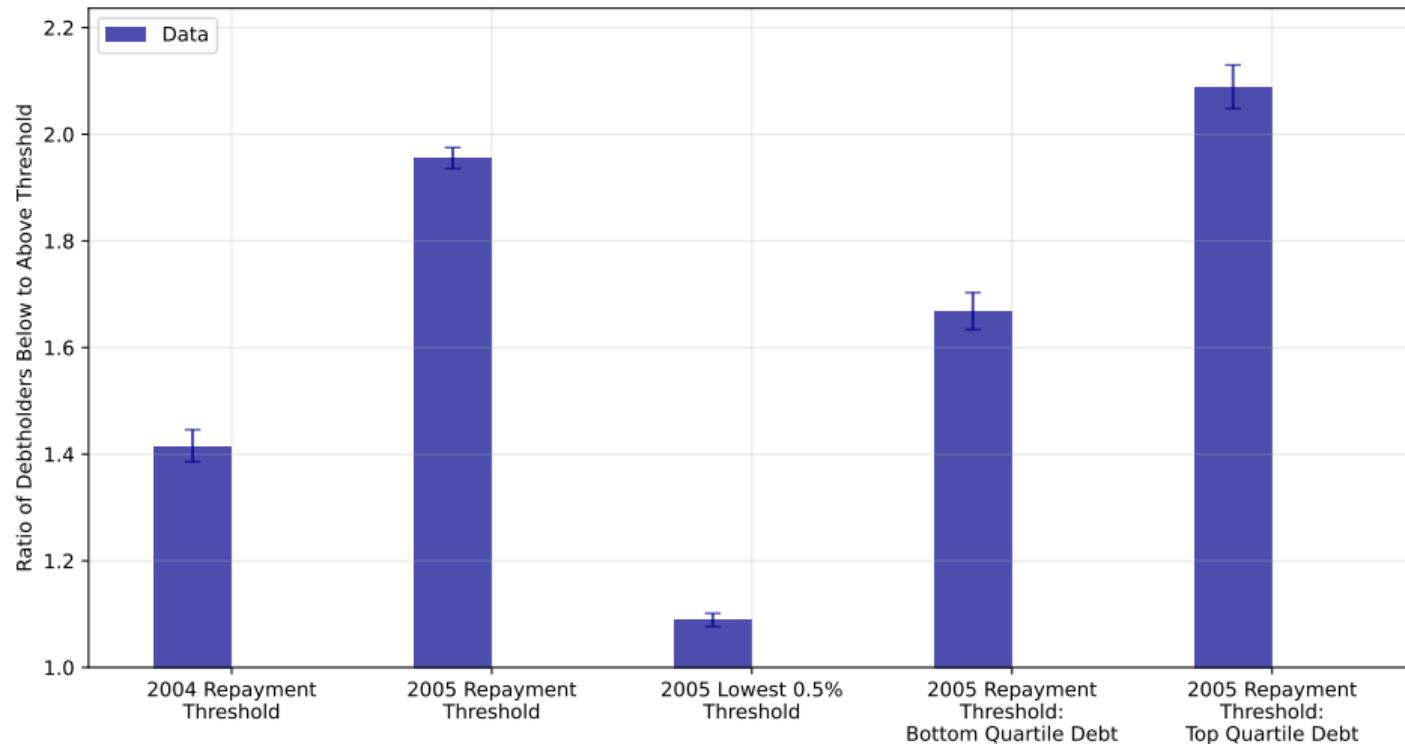
MODEL FIT: BUNCHING BEFORE AND AFTER POLICY CHANGE



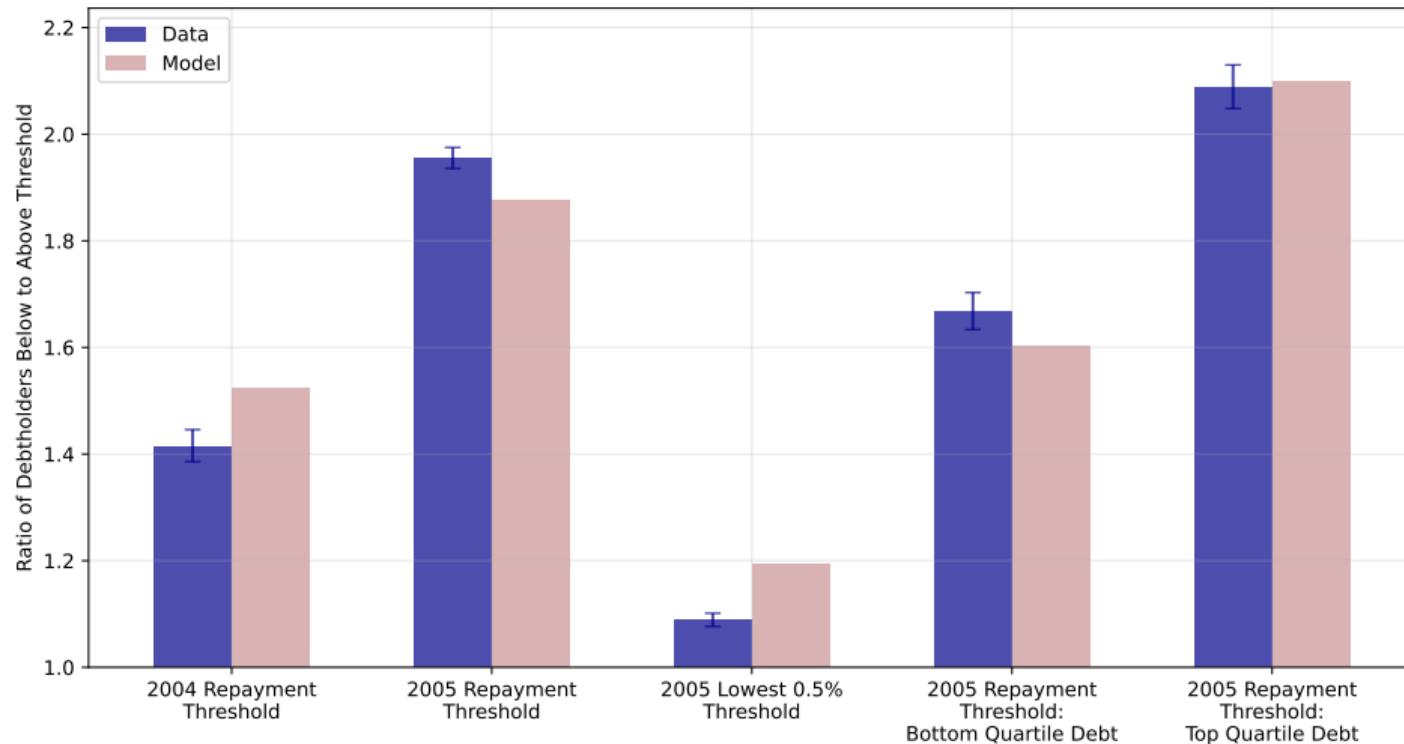
MODEL FIT: BUNCHING BEFORE AND AFTER POLICY CHANGE



MODEL FIT: BUNCHING HETEROGENEITY



MODEL FIT: BUNCHING HETEROGENEITY



► Model Fit: Other Moments

► Additional Results

OUTLINE

- 1 Institutional Background and Data
- 2 Labor Supply Responses to Income-Contingent Repayment
- 3 Life Cycle Model with Endogenous Labor Supply
- 4 Welfare Impact of Income-Contingent Repayment
- 5 Conclusion

What repayment contract best balances **insurance** with **moral hazard**?

- Consider social planner that maximizes borrower welfare with **one** contract
 - Problem faced by governments with one contract (e.g., Australia, UK)
 - Contract is subsidized with zero interest rate, borrowing & prices held fixed

What repayment contract best balances **insurance** with **moral hazard**?

- Consider social planner that maximizes borrower welfare with **one** contract
 - Problem faced by governments with one contract (e.g., Australia, UK)
 - Contract is subsidized with zero interest rate, borrowing & prices held fixed
- **Three** ways to provide **insurance**:
 - ① Within-individuals over the life cycle
 - ② Across ex-post states at each age (e.g., wage shocks)
 - ③ Across ex-ante states (e.g., initial permanent income)
- **Two** ways to create **moral hazard**: bunching + intensive-margin responses

CONSTRAINED-OPTIMAL INCOME-CONTINGENT LOANS

Find solution to **constrained**-planner's problem with income-contingent loans:

$$\max \mathbf{E}_0 \left(V_{a_0}^{1-\gamma} \right)^{\frac{1}{1-\gamma}} \quad (\text{behind the "veil-of-ignorance"})$$

CONSTRAINED-OPTIMAL INCOME-CONTINGENT LOANS

Find solution to **constrained**-planner's problem with income-contingent loans:

$$\max_{\psi, K} \mathbf{E}_0 \left(V_{a_0}^{1-\gamma} \right)^{\frac{1}{1-\gamma}}$$

subject to:

$$\text{Repayments}_a = \psi * \max \{y_a - K, 0\} \quad (\text{US/UK}) \quad (1)$$

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$$\frac{1}{\mathcal{R}_a} = \underbrace{\beta^{a-a_0}}_{\text{individual time preference}} * \underbrace{\prod_{s=0}^{a-a_0} m_s}_{\text{mortality}}$$

Robustness with \mathcal{R}_a = risk-free rate and risk-free rate + 4%

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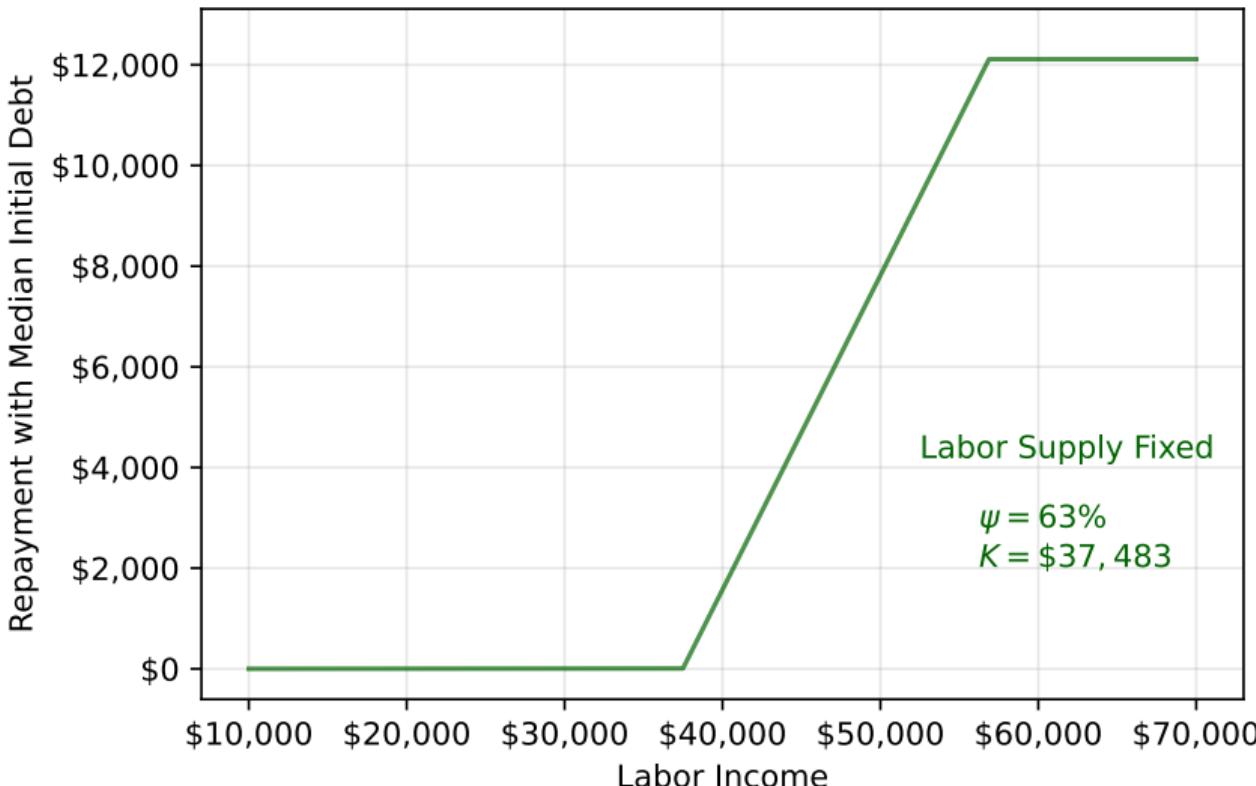
$$\text{Repayments}_a = \min \left\{ \psi * \max \{y_a - K, 0\}, D_a \right\} \quad (1)$$

$$\mathbf{E}_0 \sum_{a=a_0}^{a_T} \frac{\text{Repayments}_a + \text{Taxes}_a - \text{Transfers}_a}{\mathcal{R}_a} \geq \mathcal{G}_{25\text{-Year Fixed}} \quad (2)$$

$$\frac{1}{\mathcal{R}_a} = \underbrace{\beta^{a-a_0}}_{\text{individual time preference}} * \underbrace{\prod_{s=0}^{a-a_0} m_s}_{\text{mortality}}$$

Robustness with \mathcal{R}_a = risk-free rate and risk-free rate + 4%

SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM

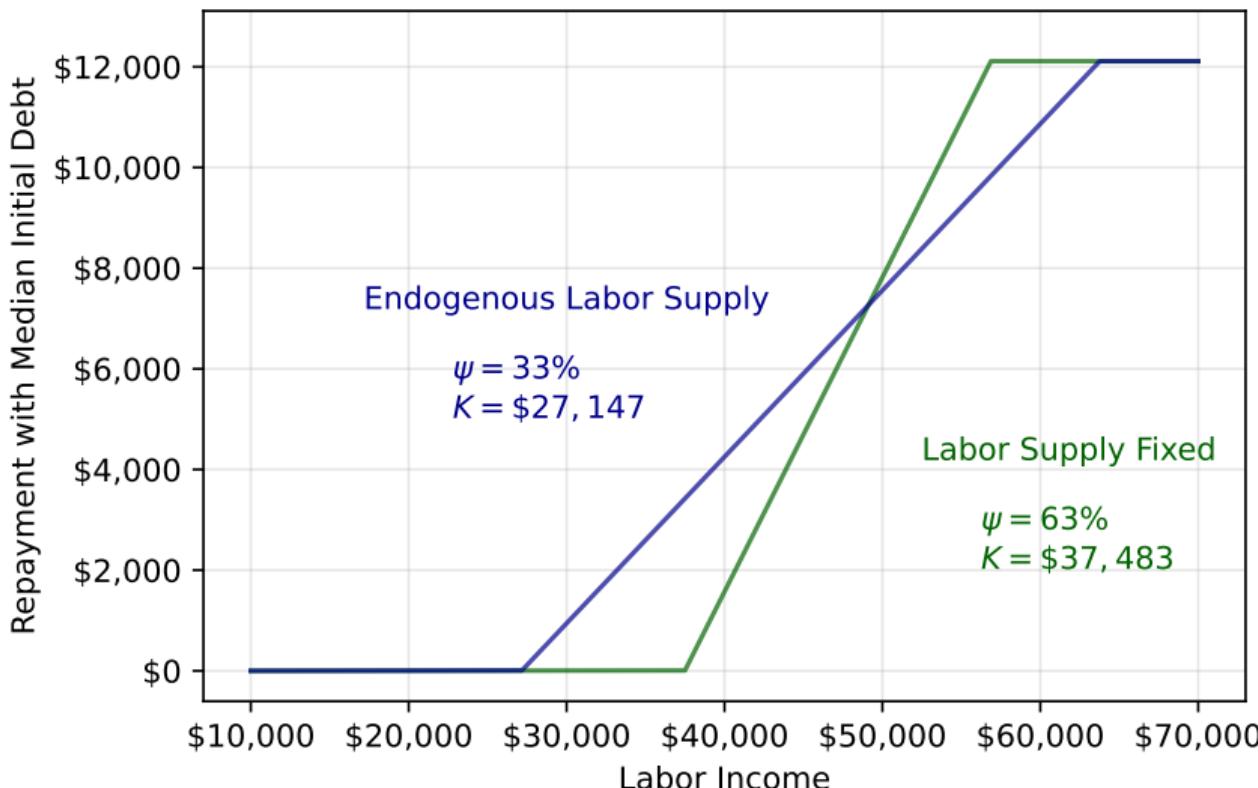


► Smooth Contract

► Compare with Existing

► Non-Budget-Neutral

SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM

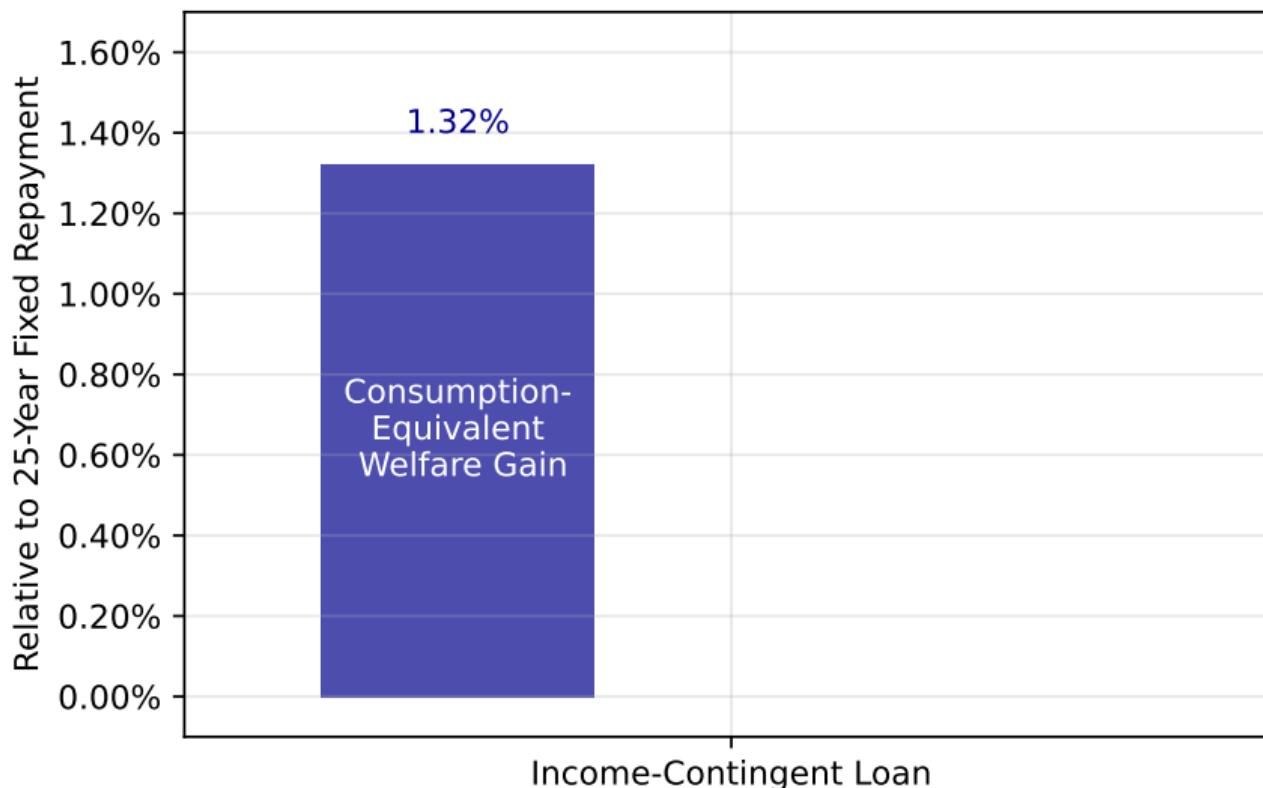


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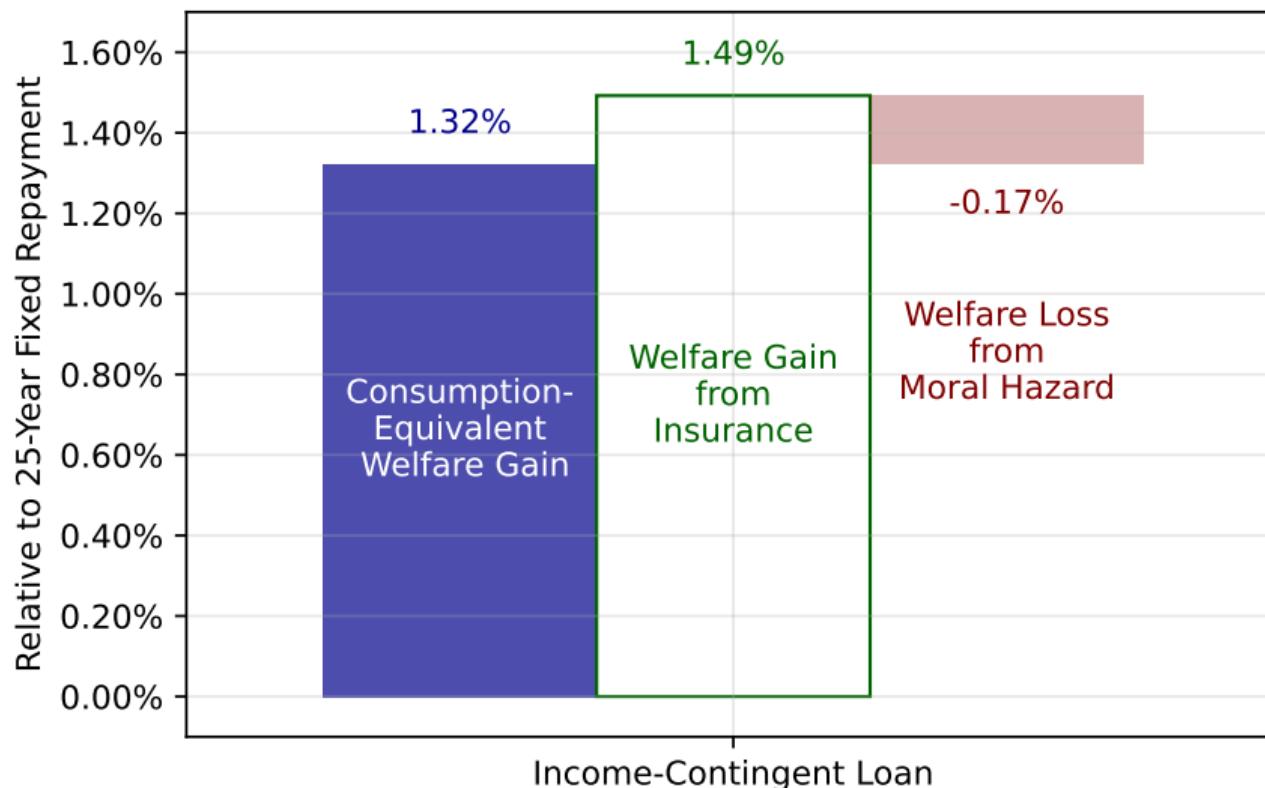
► Non-Budget-Neutral

CONSTRAINED-OPTIMUM = 1.3% INCREASE IN LIFETIME CONSUMPTION

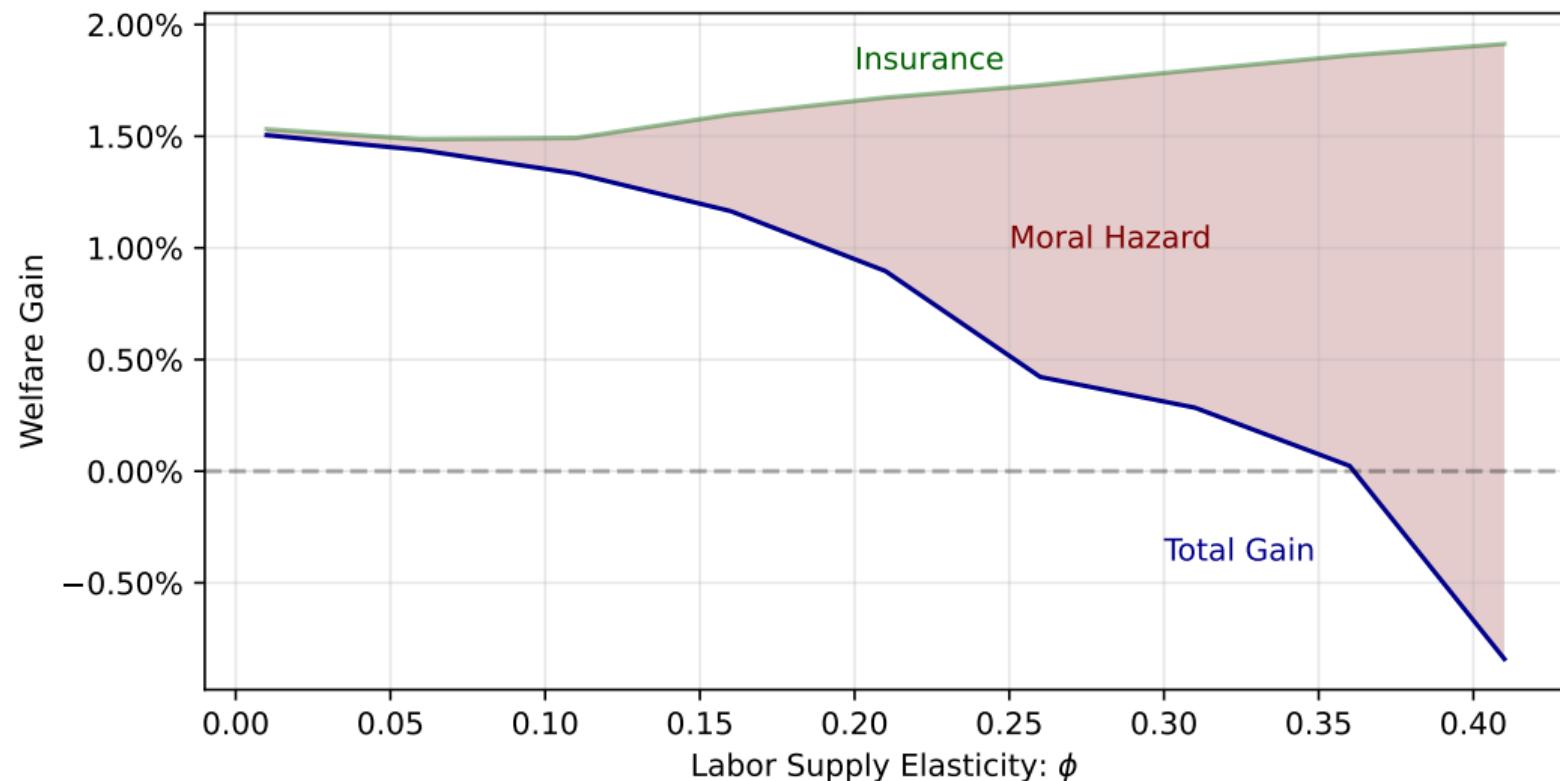


- ▶ Heterogeneity
- ▶ Restrict $\psi \leq 10\%$
- ▶ Robustness: Alt. Models
- ▶ Robustness: Frictions

CONSTRAINED-OPTIMUM = 1.3% INCREASE IN LIFETIME CONSUMPTION



WELFARE GAIN IS POSITIVE AS LONG AS $\phi < 0.37$

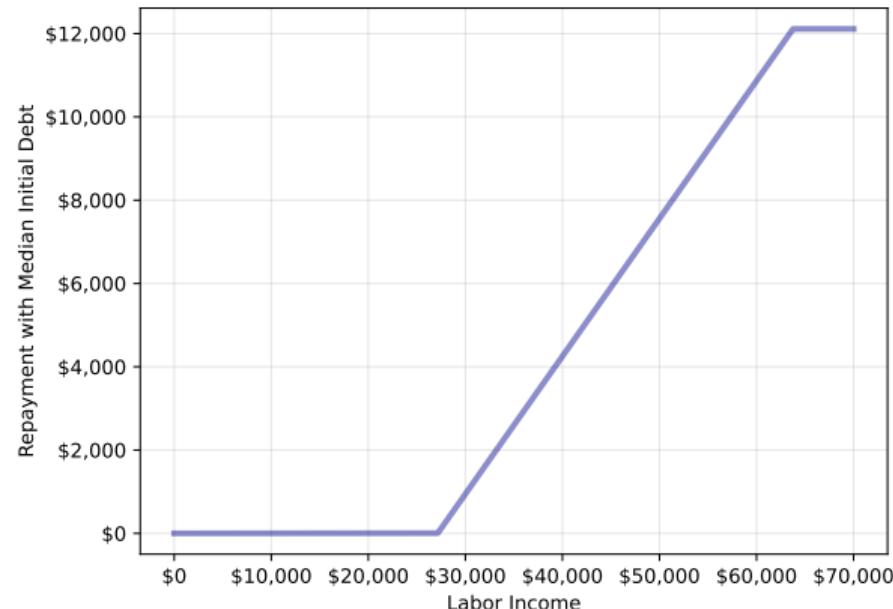
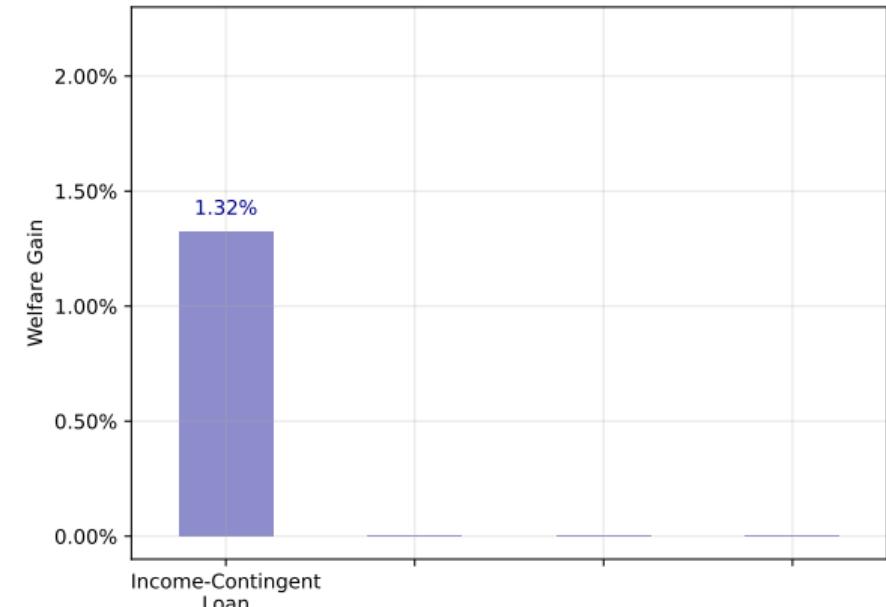


▶ Implied Bunching at $\phi = 0.37$

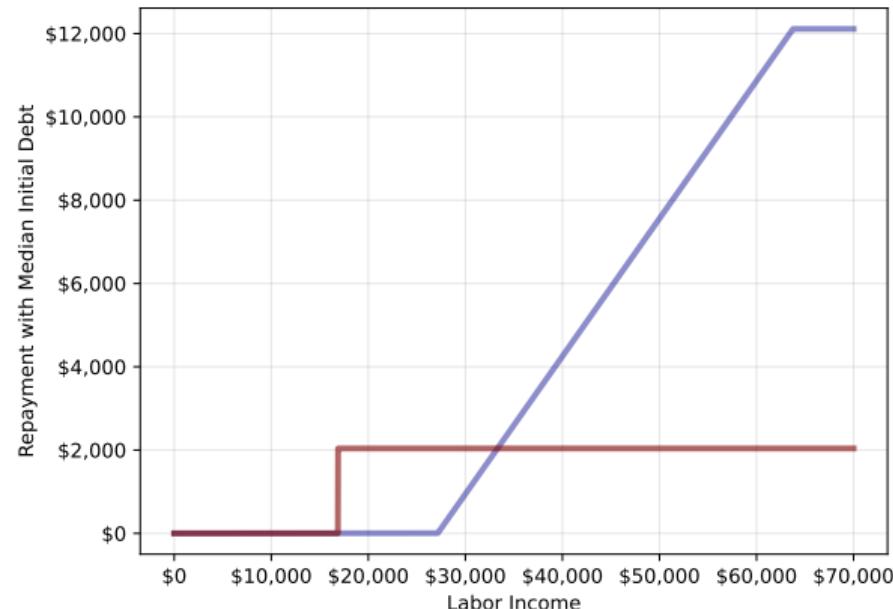
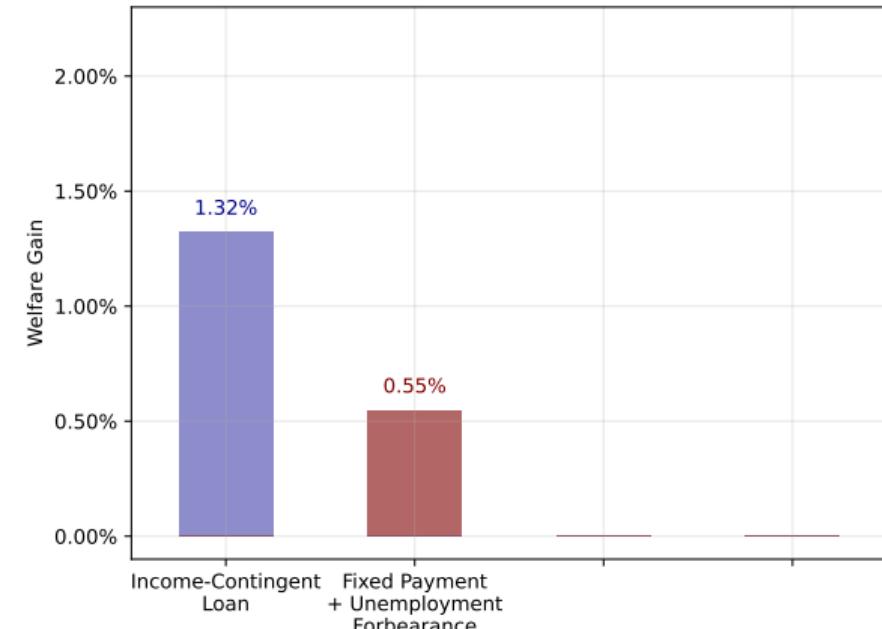
▶ Contracts by ϕ

▶ Contracts to Reduce MH

NEXT: ICLs vs. OTHER CONSTRAINED-OPTIMAL CONTRACTS...

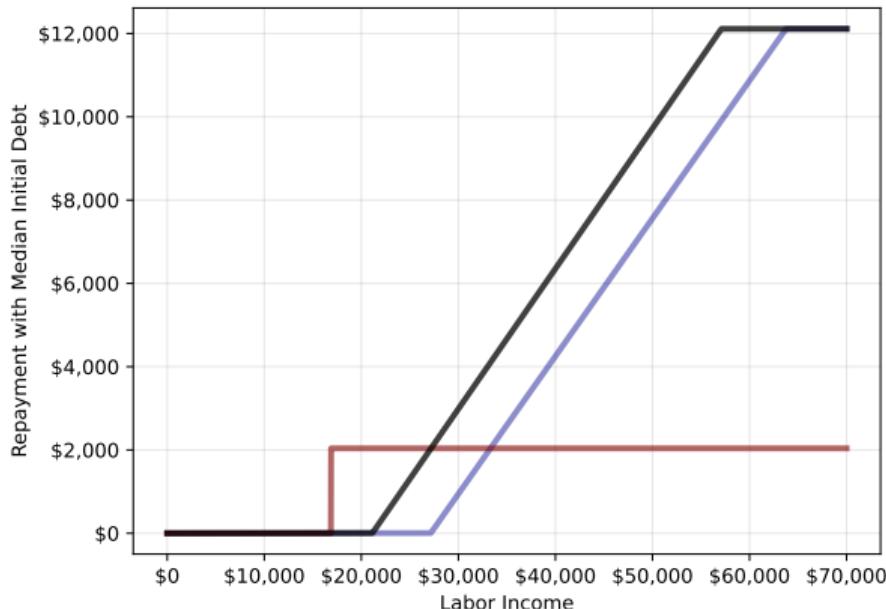
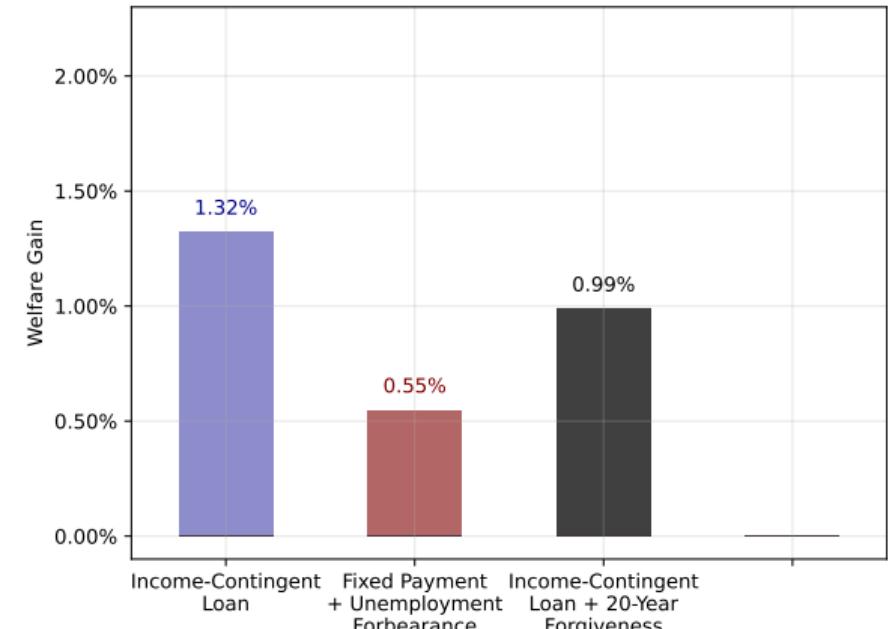


JUST PROVIDING FORBEARANCE GIVES SMALLER GAINS



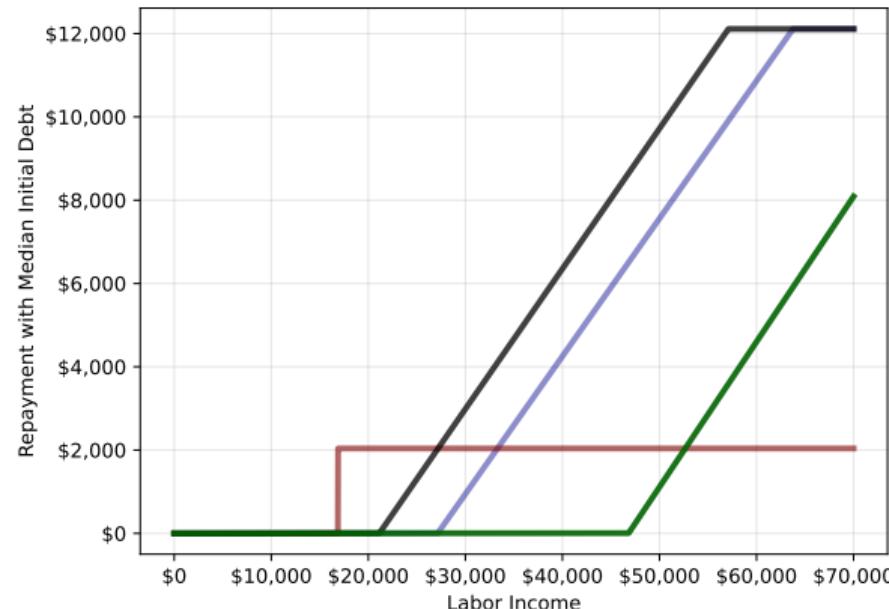
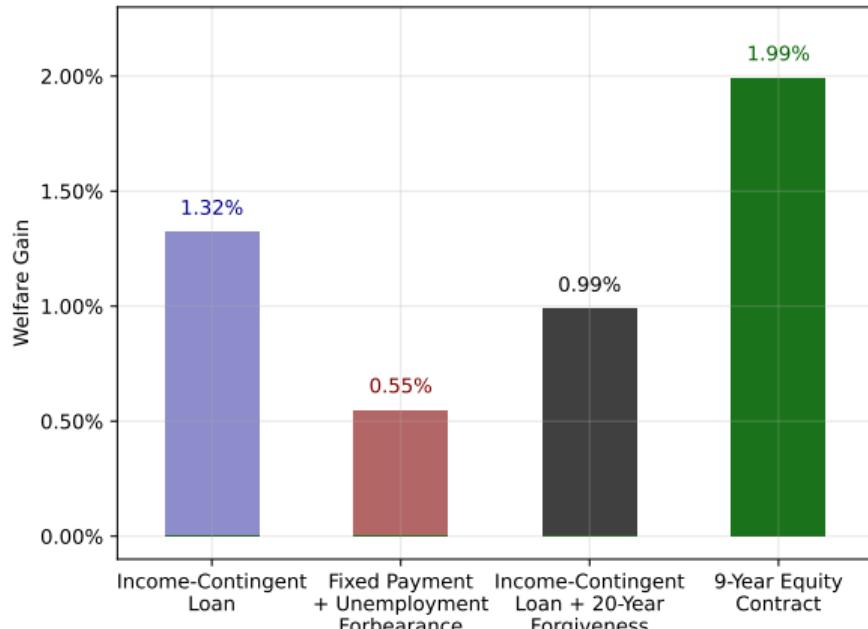
- **Benefit** of income-contingent loan: accelerate payments from high-income

ADDING FORGIVENESS REDUCES WELFARE GAINS



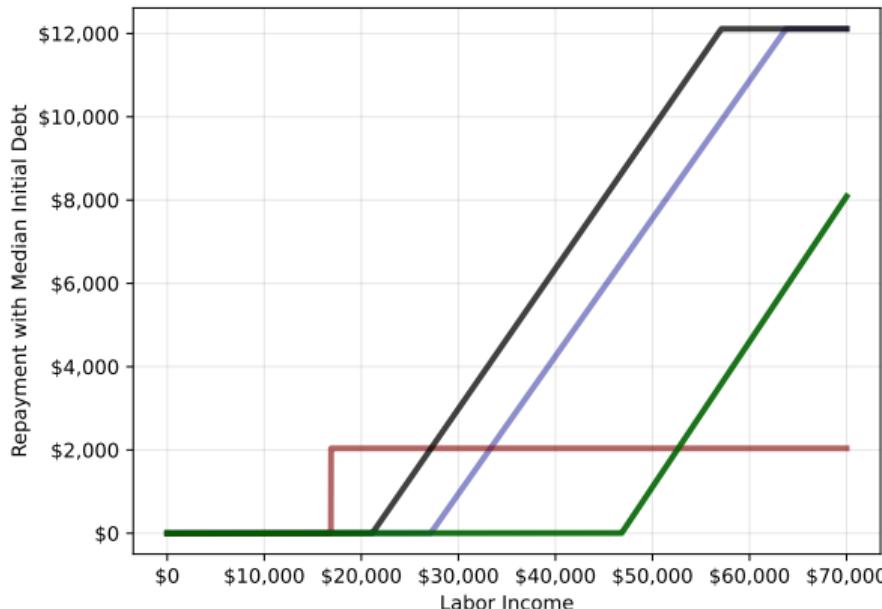
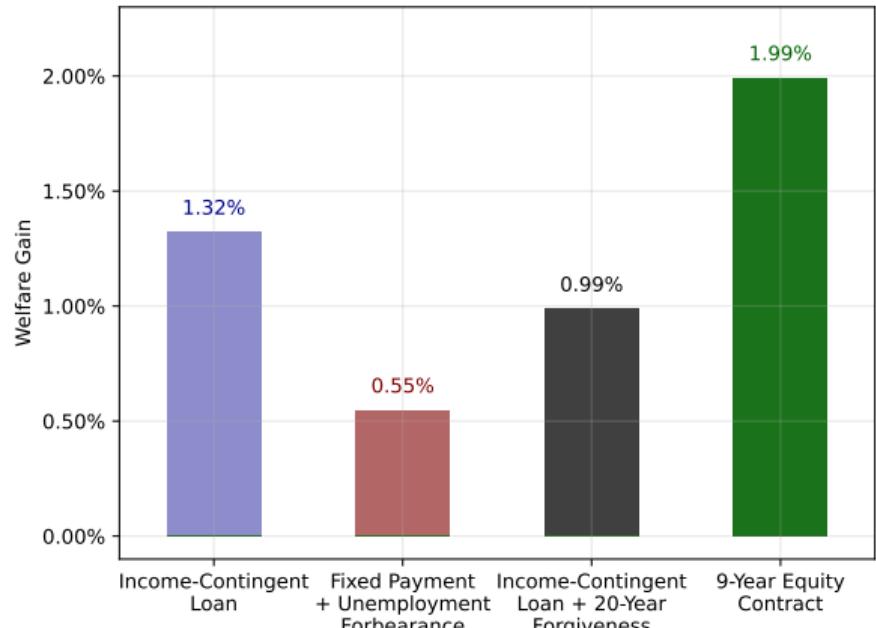
- **Costs** of forgiveness: transfer repayments to young and finite repayment horizon

EQUITY CONTRACT GIVES LARGER GAINS



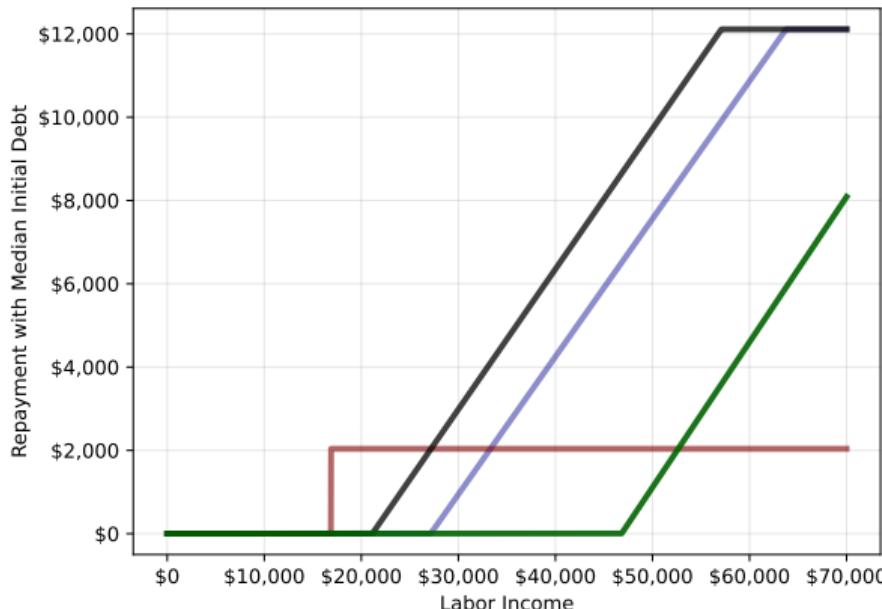
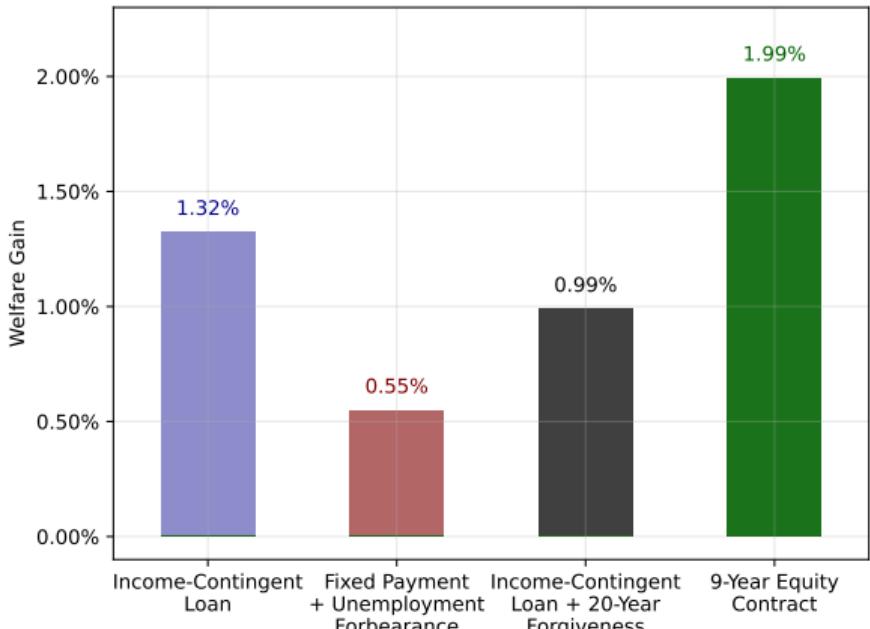
- **Benefit of equity:** uncapped payments from high-income \Rightarrow 70% higher threshold

EQUITY CONTRACT GIVES LARGER GAINS, BUT MORE DISPERSED



- **Cost** of equity: more likely to cause losses from **ex-ante** responses and **selection**

EQUITY CONTRACT GIVES LARGER GAINS, BUT MORE DISPERSED



- **Cost** of equity: more likely to cause losses from **ex-ante** responses and **selection**

► Heterogeneity ► Loss from Endogenous Selection ► Restructuring ► Additional Results

OUTLINE

- 1 Institutional Background and Data
- 2 Labor Supply Responses to Income-Contingent Repayment
- 3 Life Cycle Model with Endogenous Labor Supply
- 4 Welfare Impact of Income-Contingent Repayment
- 5 Conclusion

- US “student debt crisis”: 25% of borrowers default within 5 years of graduation
 - Possible solution = change contracts to be **income-contingent** (e.g., SAVE)
- **This paper:** evidence + model to calibrate the effects of different contracts
 - ① Ex-post moral hazard is not a reason to avoid **income-contingent** contracts
 - ② Among these contracts, **income-contingent loans** are relatively effective and robust
- **Open question:** effects of income-contingent contracts on ex-ante choices?
- **Broader question:** is more state-contingent repayment useful for other liabilities?
 - HHs: government-provided shared-appreciation mortgages (UK, Canada)
 - Firms: revenue-based financing

THANK YOU!

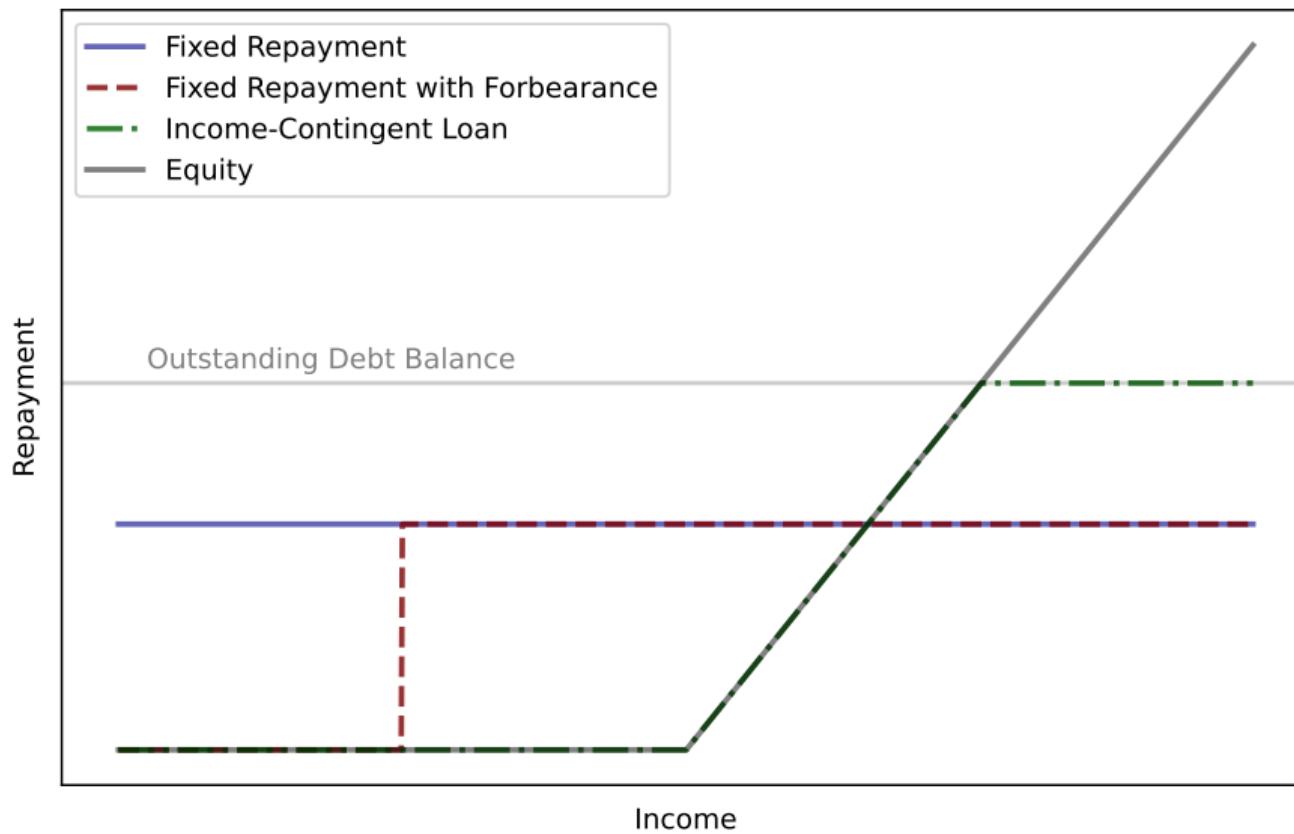
www.timdesilva.me

tdesilva@mit.edu

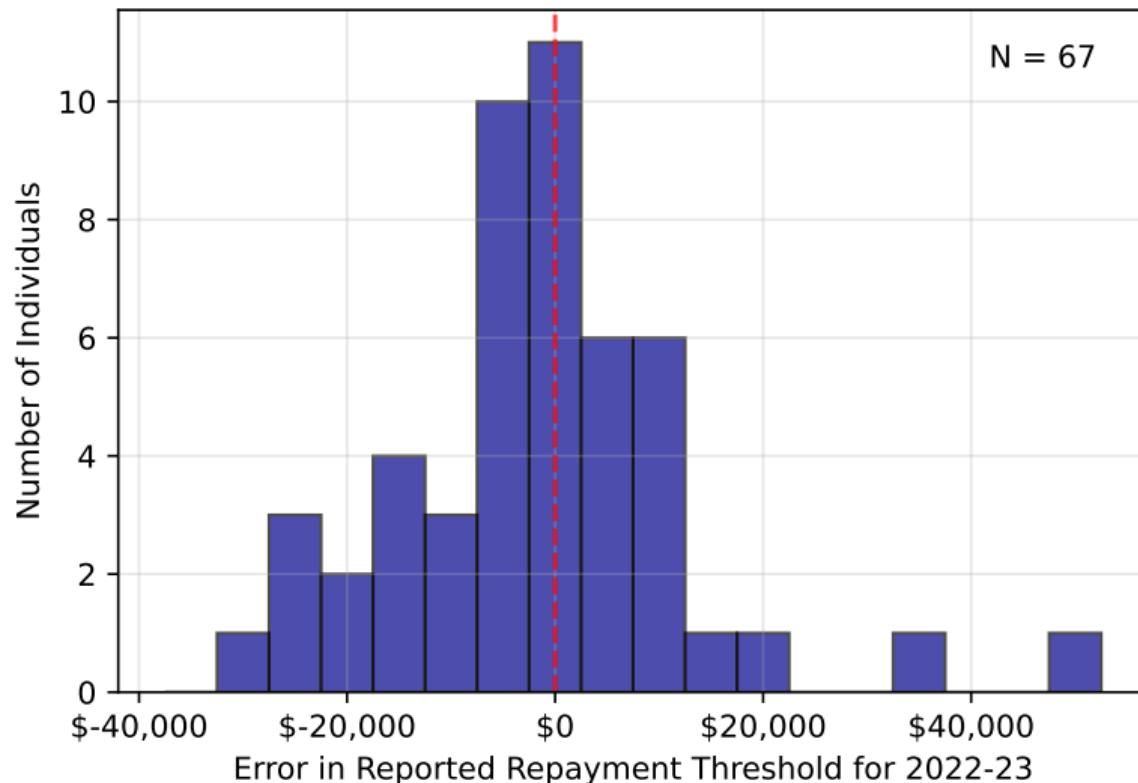
APPENDIX

START OF APPENDIX

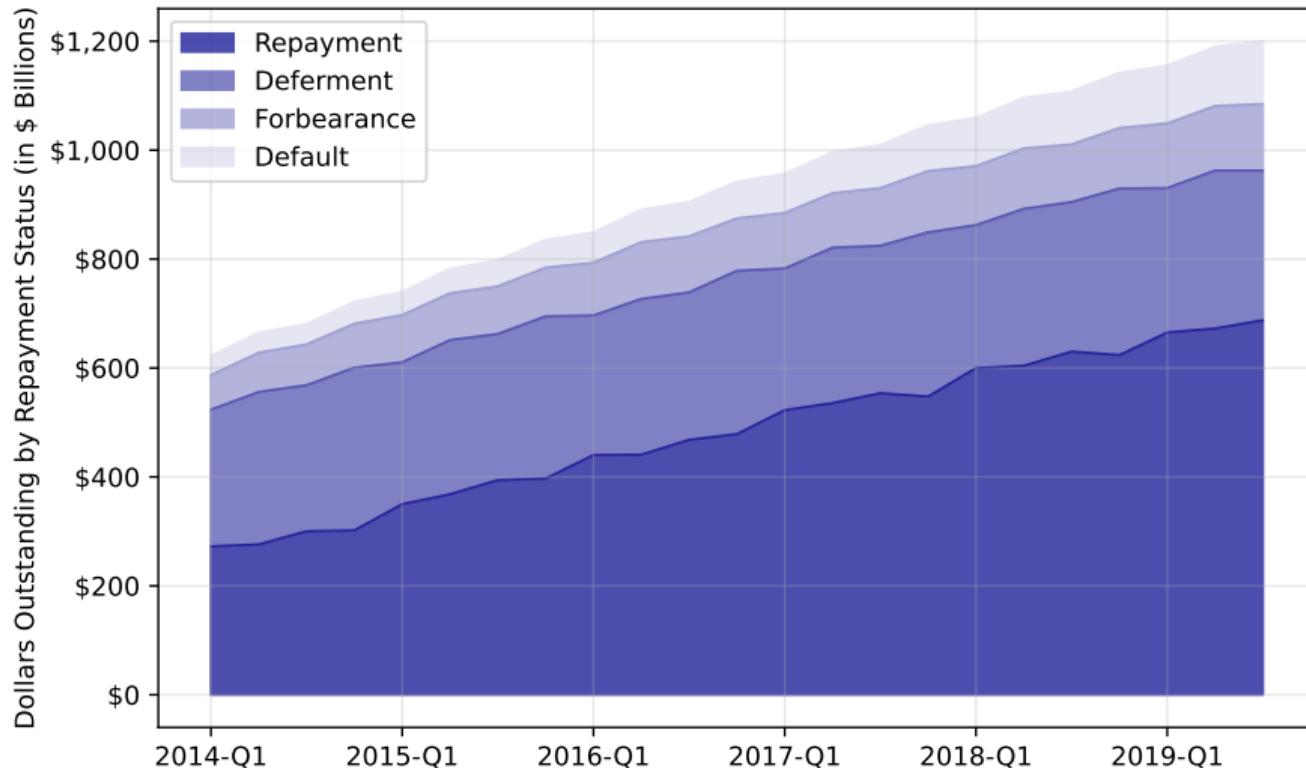
ILLUSTRATION OF DIFFERENT REPAYMENT CONTRACTS



SURVEY OF THRESHOLD LOCATION



REPAYMENT STATUS OF US STUDENT LOANS



PREVALENCE OF GOVERNMENT-PROVIDED INCOME-CONTINGENT LOANS

- Countries with **universal** adoption: Australia (1989), New Zealand (1991), UK (1998), Hungary (2001)
- Countries with **partial** adoption: US (1994), Thailand (2006), South Korea (2009), Brazil (2016), the Netherlands (2016), Japan (2017), Canada (2017), Colombia (2023)
- Countries **considering** adoption (as of 2022): Chile, France, Malaysia, Ireland

Source: Chapman-Dearden 2022

◀ Back

VARIABLE DEFINITIONS

- HELP Income = Taxable Income + Fringe Benefits + Foreign Employment Income + Investment or Property Losses + Employer Super Contributions
- Labor Income = Salary/Wages + Allowances & Tips + Self-Employment Income
- Capital Income = Interest and Dividend Income + Annuity Income + Capital Gains + Rental Income + Managed Trust Income
- Net Deductions = Labor Income + Capital Income - HELP Income

◀ Back

AU-US DIFFERENCES MOST LIKELY TO AFFECT CONTRACT DESIGN

- ① More debt in US due to higher tuition, longer degrees, and discretionary items
 - Larger demand for insurance in US, but also more moral hazard
 - Discretionary borrowing in US ⇒ possible ex-ante moral hazard
- ② Active private market in US cream-skims high-income borrowers Bachas 2019
 - Amount of insurance that can be provided might be lower in US
- ③ Student loans more subsidized in Australia than US
 - Different moral hazard in US (if there is selection on moral hazard) Karlan-Zinman 2009
- ④ Tuition and enrollment caps at public universities in Australia
 - Supply-side responses could increase fiscal cost of ICLs in US Kargar-Mann 2023
 - Note: I compare contracts with identical subsidy

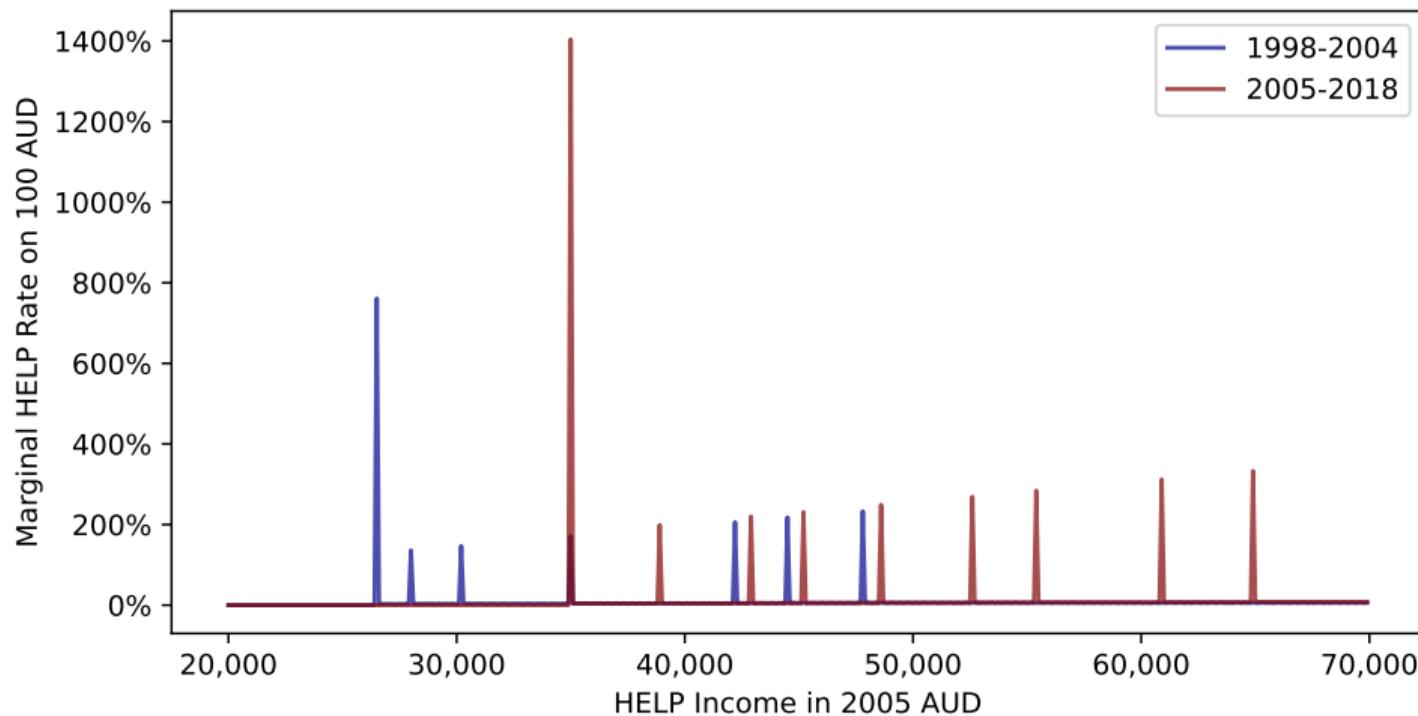
DIFFERENCES BETWEEN AUSTRALIA AND US: STATISTICS

| Feature of Environment | Australia | US |
|--|--|--|
| Cost of Higher Education | | |
| Public Undergraduate Tuition Cost | \$2,700–\$10,100 USD per year for CSPs | \$9,500 USD per year for 4-Year In-State \$39,000 USD per year for 4-Year Private Nonprofit |
| Total Cost of Attendance | \$15,850 USD per year | \$22,700 USD per year |
| Prevalence of Scholarships | Rare | Common |
| Initial Student Debt Borrowed | \$8,100–\$30,300 USD | \$51,800 USD (Average) |
| Student Population | | |
| % of Population with Undergraduate Degree | 38% | 32% |
| % of Undergraduates at Private Universities | 6% | 26% |
| % of Undergraduates from Abroad | 16% | 5% |
| % of Current Students Employed | 50% | 40% |
| Income Distribution and Taxes/Transfers | | |
| Median Personal Income | \$33,500 USD | \$40,500 USD |
| Poverty Line for Single Individual | \$16,200 USD | \$14,580 USD |
| Gini Coefficient for Income | 0.32 | 0.38 |
| Marginal Tax Rate at Average Income | 41% | 41% |
| Heathcote et al. (2017) Tax Progressivity | 0.133 | 0.184 |
| 1-Month Individual UI Replacement Rate | 23% | 35% |
| Union Membership Rate | 13.7% | 10.3% |

◀ Back: Benefits

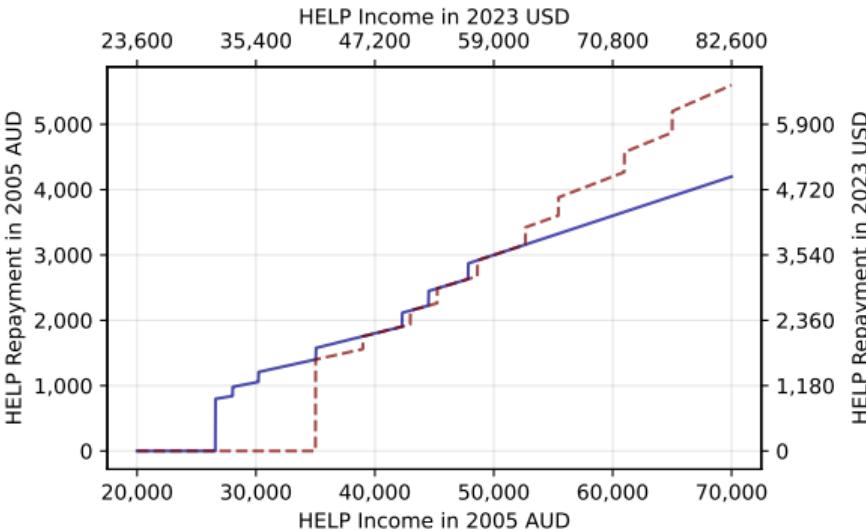
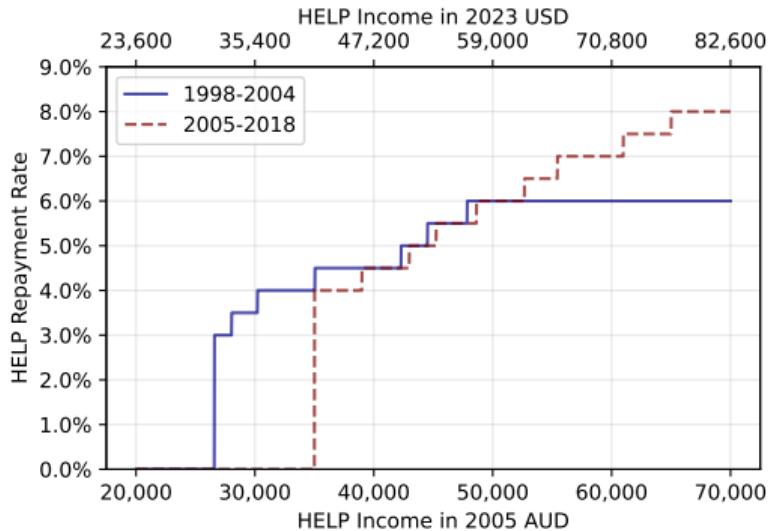
◀ Back: Differences

MARGINAL HELP REPAYMENT RATES ON 100 AUD



◀ Back

HELP REPAYMENT RATES AND REPAYMENTS



◀ Back

NEWS ARTICLE: POLICY CHANGE



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Ease HECS burden on students, say universities

Kate Marshall

Jan 9, 2003 – 11.00am



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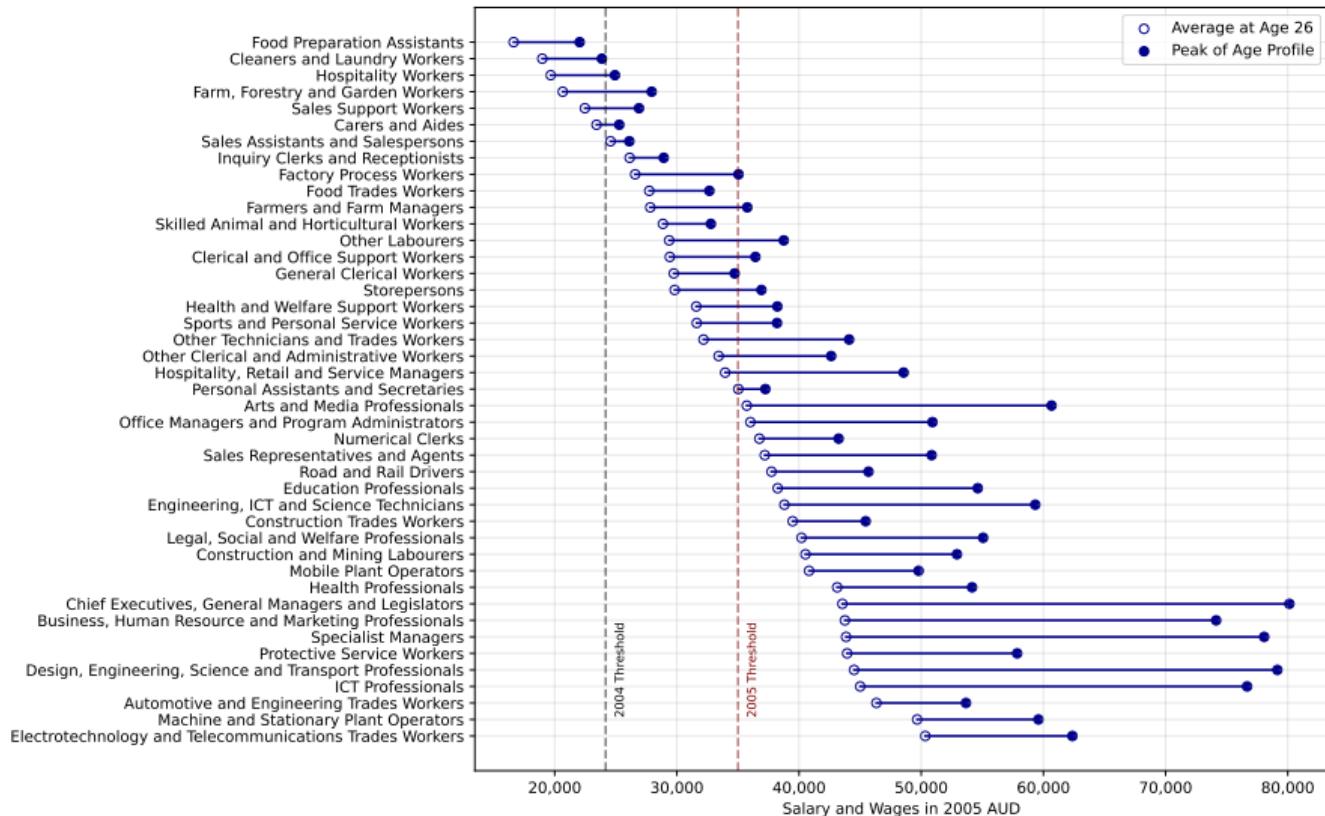


Share

Australian students owing more than \$9 billion of debts to the federal government should be spared financial heartache under a proposal to lift the income threshold for repayments, the Australian Vice-Chancellors Committee said yesterday.

◀ Back

OCCUPATION-SPECIFIC INCOME PROFILES RELATIVE TO THRESHOLDS



◀ Back: Policy

◀ Back: Hours

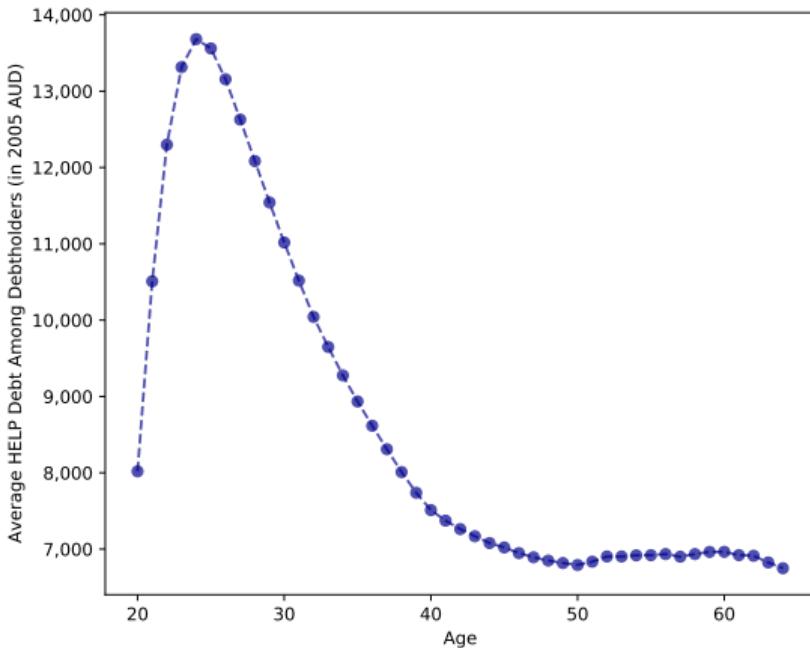
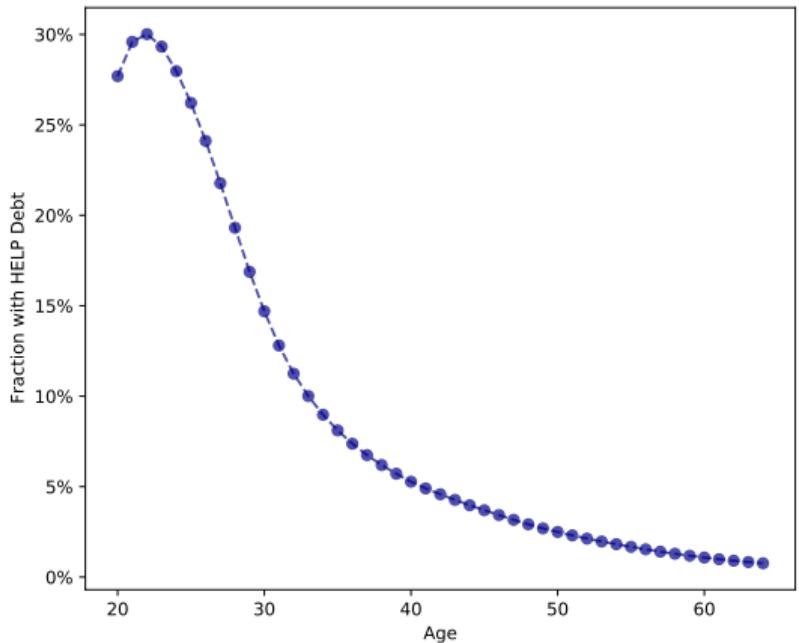
◀ Back: Table

SUMMARY STATISTICS

| | Non-Debtholders (1) | Debtholders (2) |
|--|------------------------|--------------------|
| Demographics | | |
| Age | 41.1 | 29.5 |
| Female | 0.46 | 0.60 |
| Wage-Earner | 0.85 | 0.91 |
| Income Totals (in 2005 AUD) | | |
| Taxable Income | 37,695 | 27,796 |
| HELP Income | 38,756 | 28,586 |
| Income Components (in 2005 AUD) | | |
| Salary & Wages | 32,415 | 26,068 |
| Labor Income | 35,480 | 27,136 |
| Interest & Dividend Income | 726 | 242 |
| Capital Income | 1,221 | 324 |
| Net Deductions | -1,548 | -1,099 |
| HELP Variables | | |
| HELP Debt (in 2005 AUD) | . | 10,830 |
| HELP Payment (in 2005 AUD) | . | 991 |
| HELP Debt at Age 26 (in 2005 AUD) | . | 13,156 |
| HELP Payment at Age 26 (in 2005 AUD) | . | 1,305 |
| HELP Income < 0% Threshold | 0.50 | 0.65 |
| HELP Income < 2004 0% Threshold | 0.37 | 0.51 |
| HELP Income < 2005 0% Threshold | 0.52 | 0.67 |
| Number of Unique Individuals | 19,484,517 | 4,013,382 |
| Number of Individual-Year Observations | 247,118,713 | 27,316,037 |

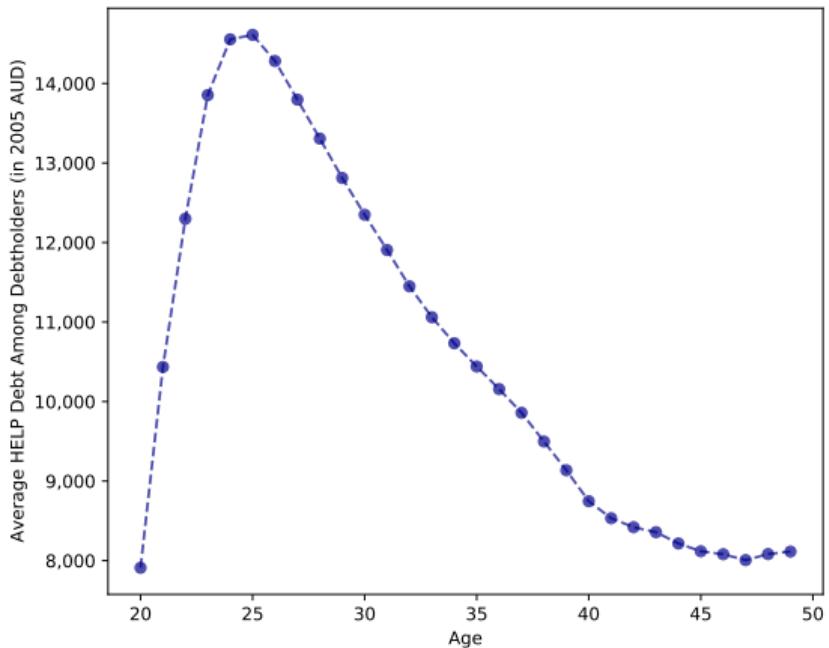
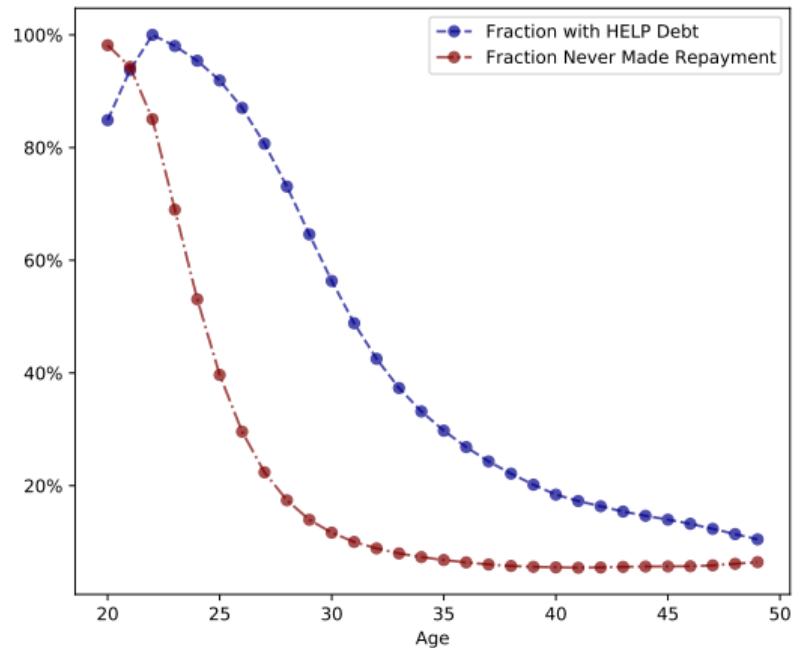
◀ Back

DEBT BALANCES BY AGE



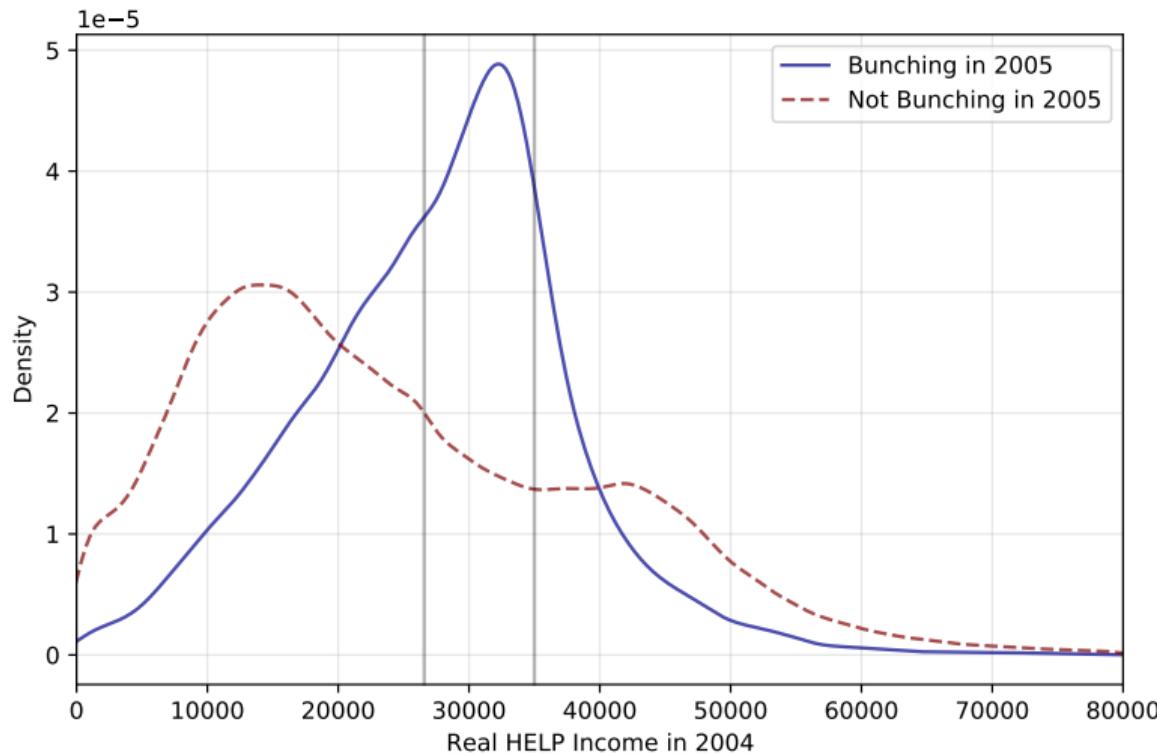
◀ Back

DEBT BALANCES BY AGE: INDIVIDUALS WITH POSITIVE DEBT AT AGE 22



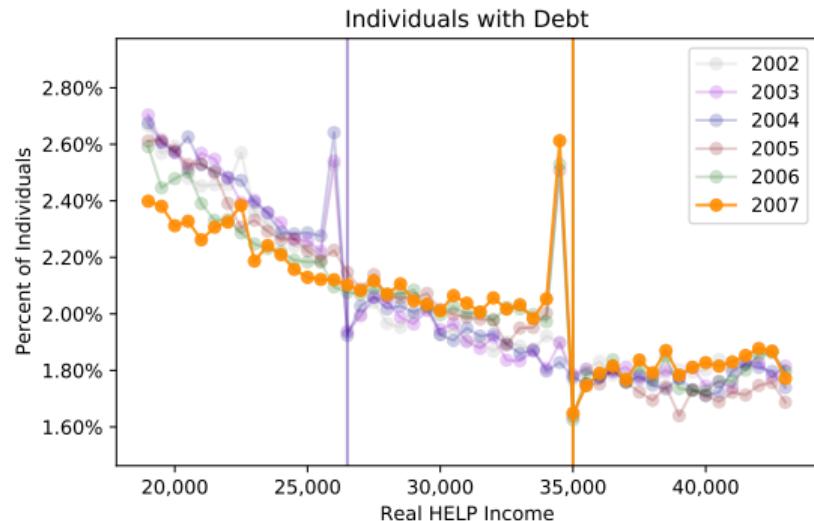
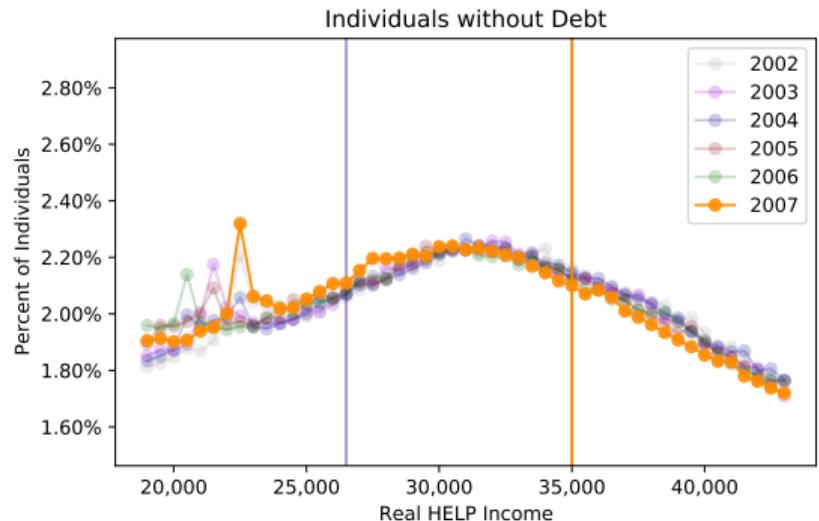
◀ Back

NEW BUNCHING COMES FROM BETWEEN OLD AND NEW THRESHOLDS



◀ Back

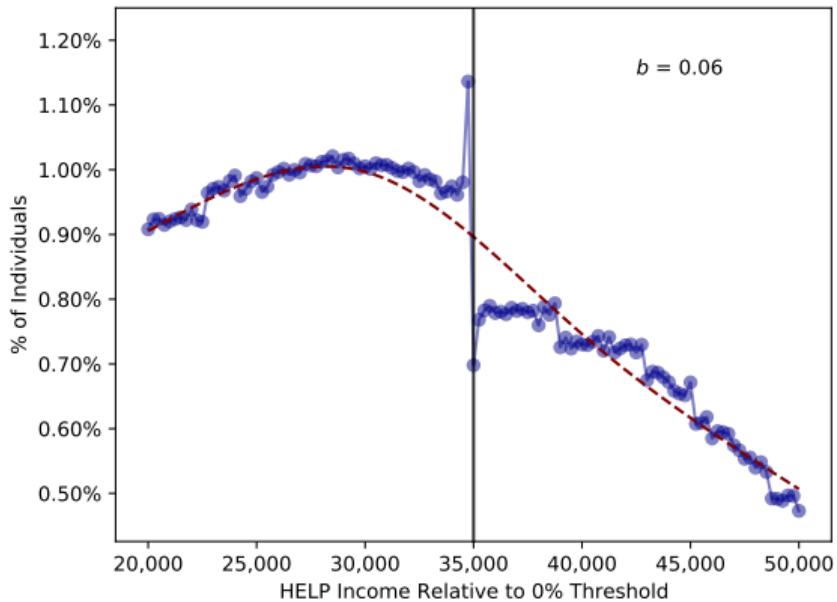
No BUNCHING AT REPAYMENT THRESHOLD FOR NON-DEBTHOLDERS



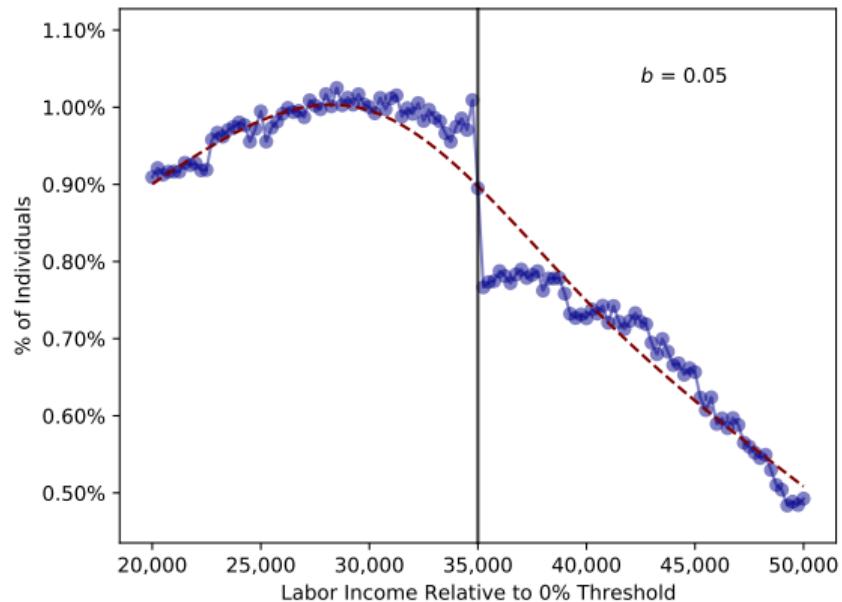
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BUNCHING IN LABOR INCOME = 83% OF BUNCHING IN HELP INCOME

HELP Income

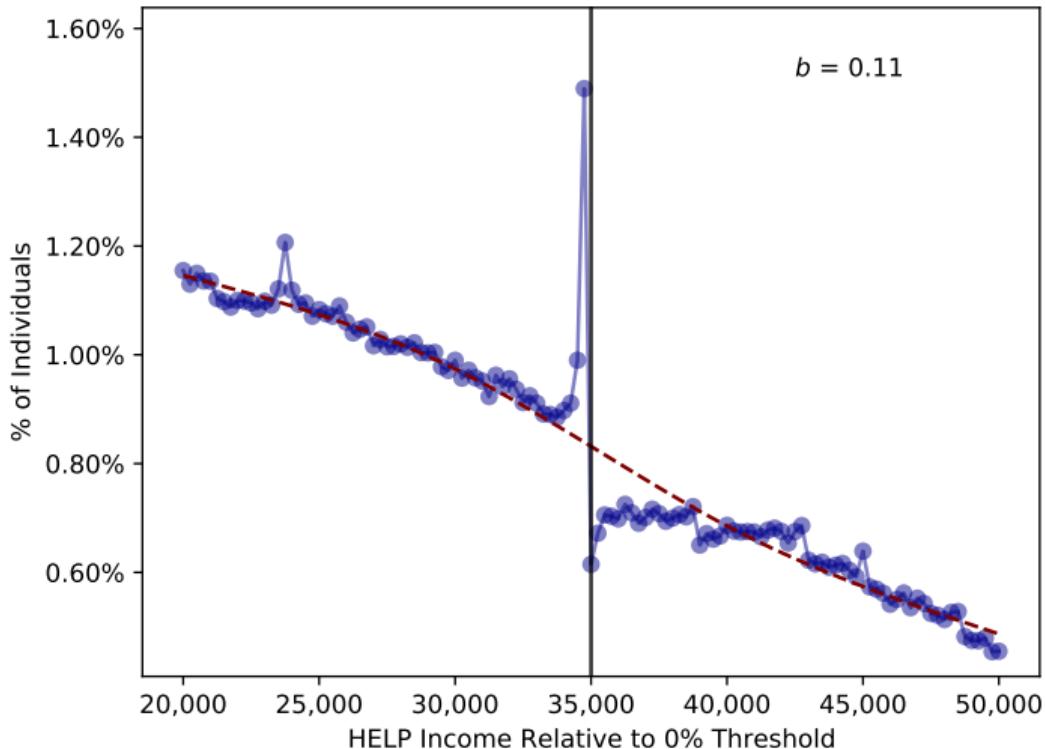


Labor Income



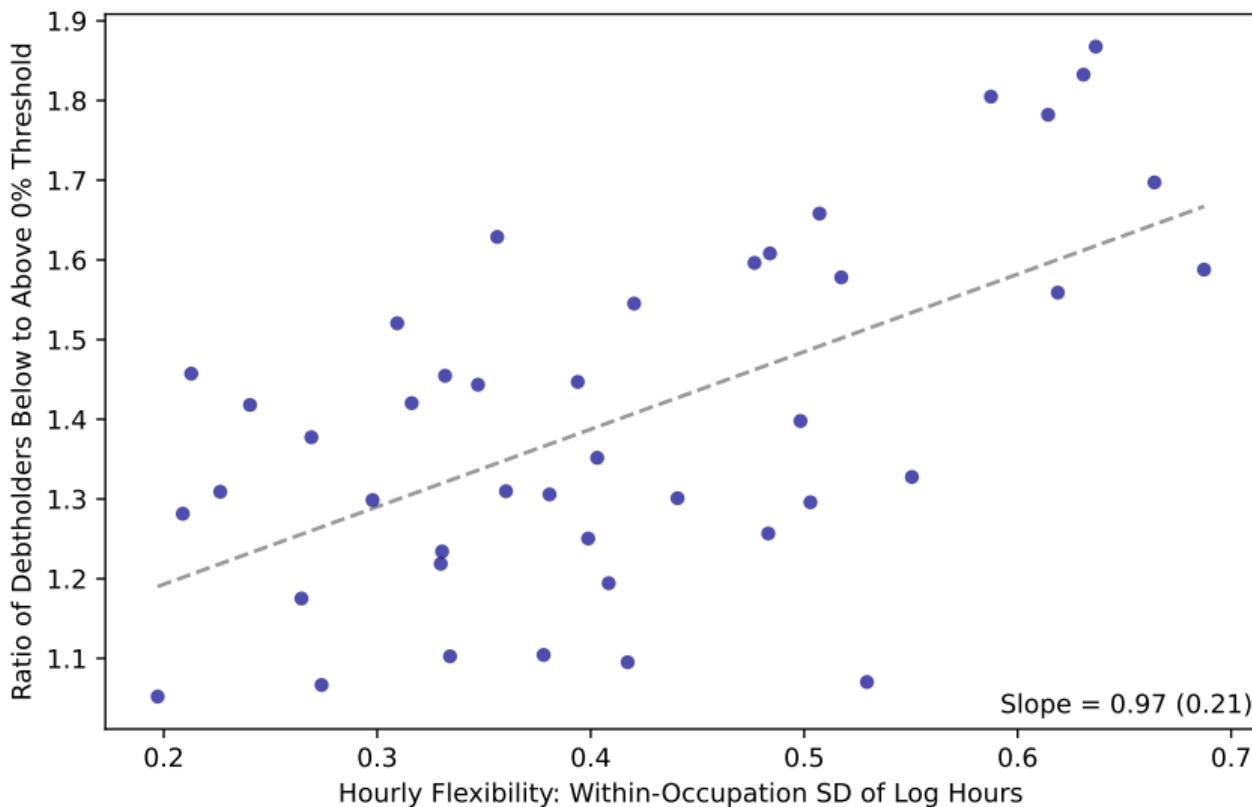
◀ Back

BUNCHING AT THRESHOLD IS LARGER THAN AT TAX KINK: 2016



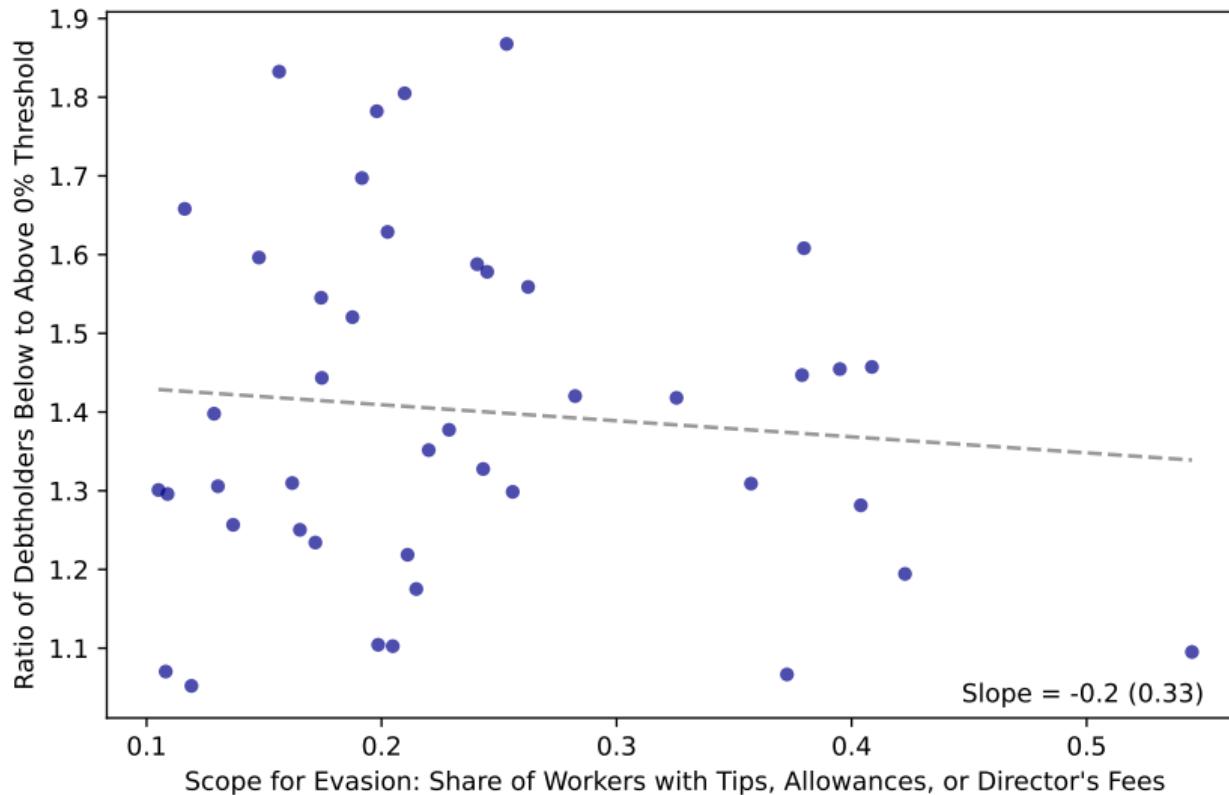
◀ Back

ALTERNATIVE MEASURE OF HOURLY FLEXIBILITY



◀ Back

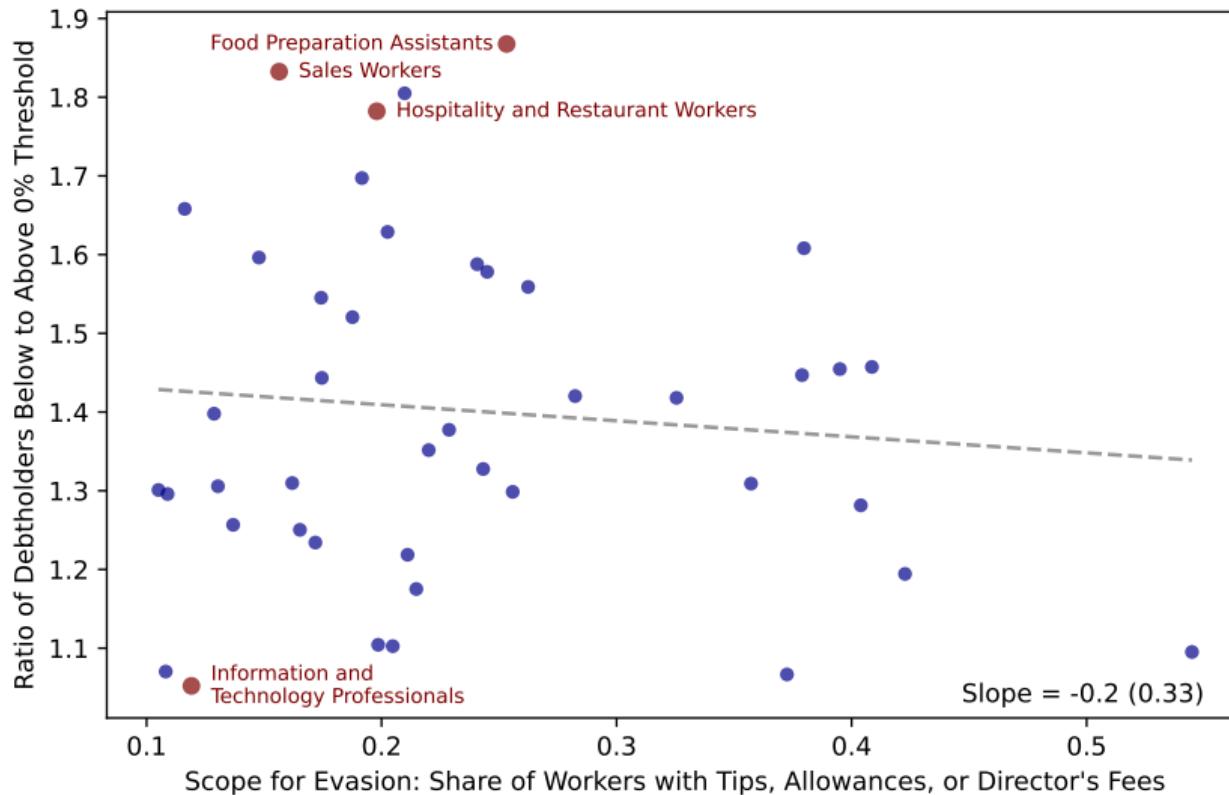
BUNCHING UNCORRELATED WITH MEASURE OF EVASION



Easier to misreport non-salary and wage income Paetzold-Winner 2016, Slemrod 2019

◀ Back

BUNCHING UNCORRELATED WITH MEASURE OF EVASION



Easier to misreport non-salary and wage income Paetzold-Winner 2016, Slemrod 2019

◀ Back

OCCUPATION-LEVEL REGRESSIONS

| | Ratio of Debtholders Below to Above Threshold | | | | | | |
|---|---|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Hourly Flexibility: SD of Changes in Log Hours | 1.30 (0.35) | . | . | . | 1.30 (0.35) | 1.05 (0.28) | 0.50 (0.23) |
| Evasion: Share with Non-Wage Income | . | -0.20 (0.30) | . | . | -0.02 (0.30) | -0.17 (0.30) | 0.05 (0.25) |
| Income Slope: Mean Wage at 45 / Mean Wage at 26 | . | . | -0.53 (0.10) | . | . | -0.40 (0.12) | . |
| Income Peak: Maximum Wage in Occupation Profile | . | . | . | -0.48 (0.06) | . | . | -0.40 (0.07) |
| <i>R</i> ² | 0.34 | 0.01 | 0.23 | 0.58 | 0.34 | 0.46 | 0.62 |
| Number of Occupations | 43 | 43 | 43 | 43 | 43 | 43 | 43 |

[▶ Profiles](#)
[◀ Back: Hours](#)
[◀ Back: Slope](#)
[◀ Back: Summary](#)

COMPUTATION OF BUNCHING STATISTIC

- Bunching statistic calculated as in prior literature Chetty et al. 2011, Kleven-Waseem 2013

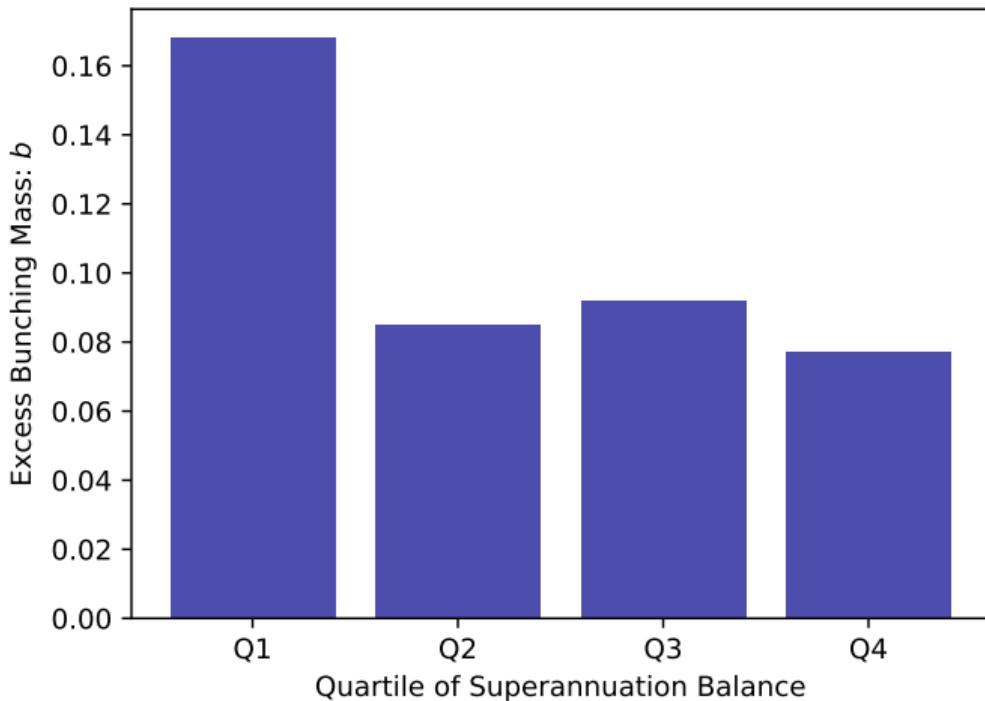
- Fit 5-piece spline leaving out $[\$32,500, \$35,000 + X]$ \Rightarrow **counterfactual density**
- Iterate and choose X so that counterfactual density integrates to 1
-

$$b = \frac{\text{observed mass in } [\$32,500, \$35,000]}{\text{counterfactual mass in } [\$32,500, \$35,000]} - 1$$

- $b = 0.1 \Rightarrow$ 10% more people below threshold than would be absent discontinuity
 - Note: normalization makes b comparable across distributions of different shapes
- Sample:** All debtholders age 20 to 64 pooled across 2005 to 2018
 - Income deflated to 2005 so 0% threshold constant in real terms at **\$35,000**

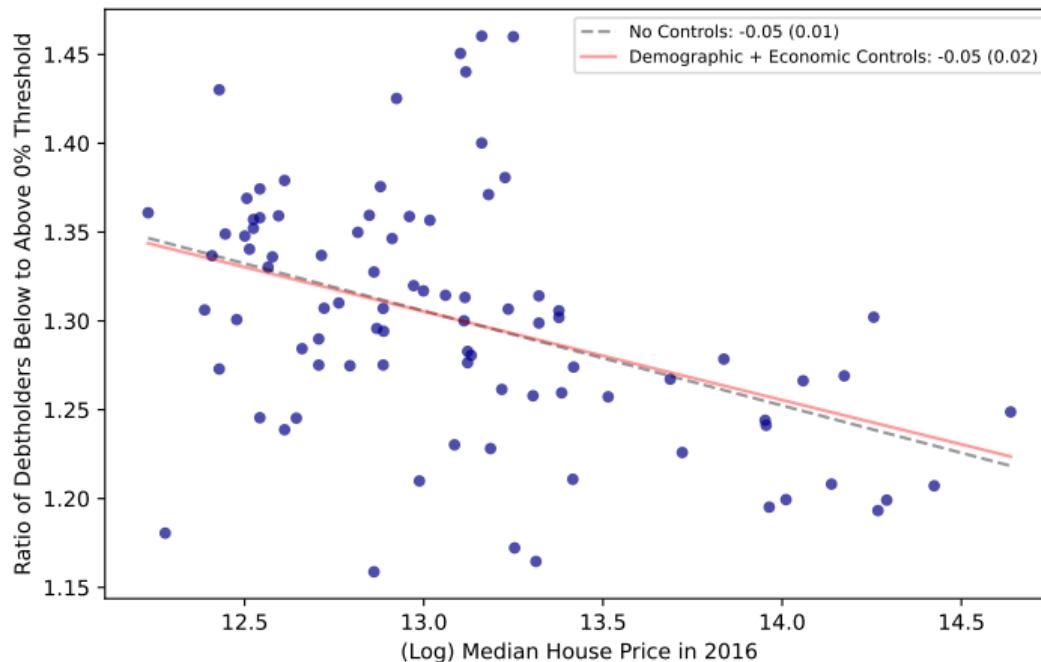
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BUNCHING HETEROGENEITY BY SUPER WEALTH: AGES 20-29



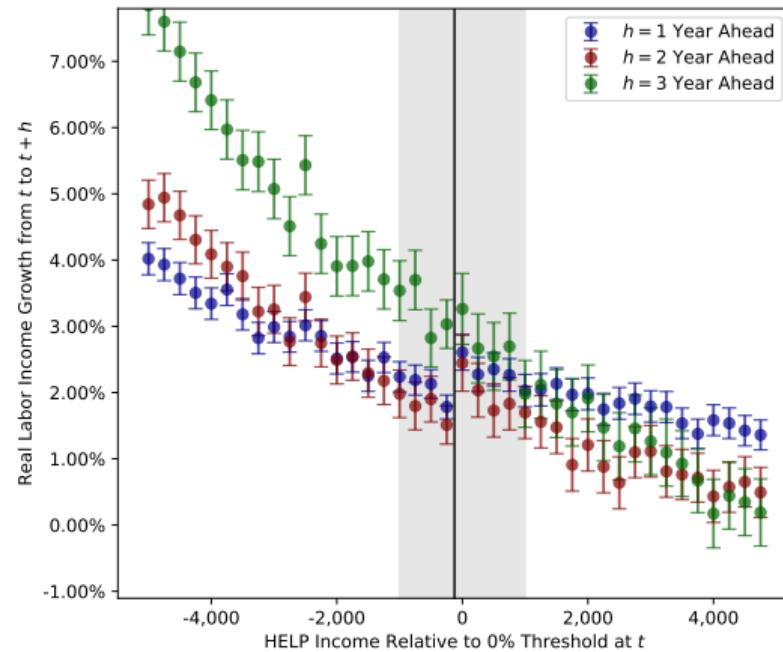
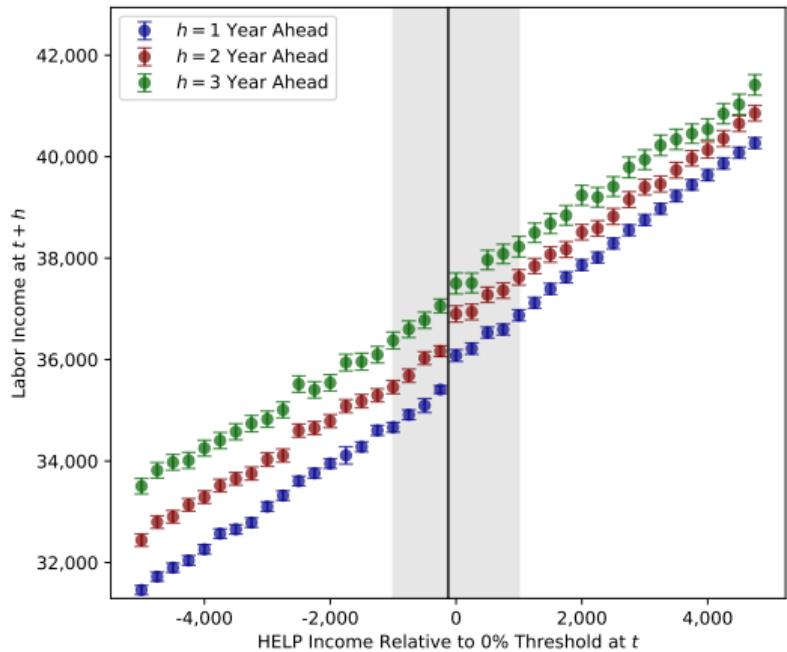
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LESS BUNCHING IN REGIONS WITH MORE HOUSING WEALTH



◀ Back

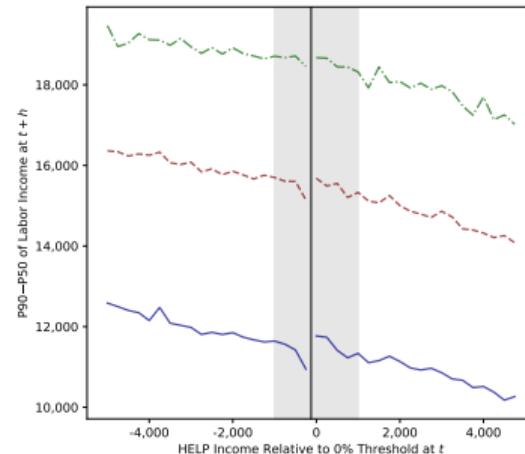
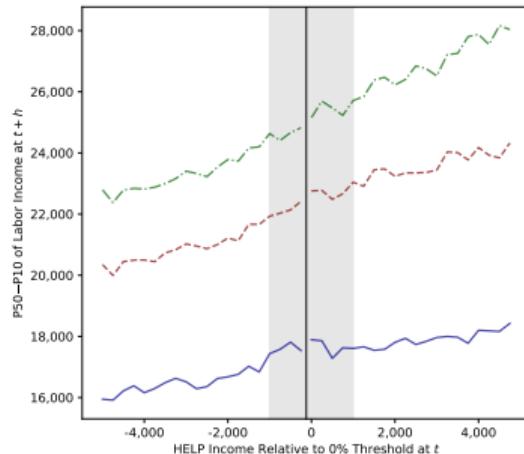
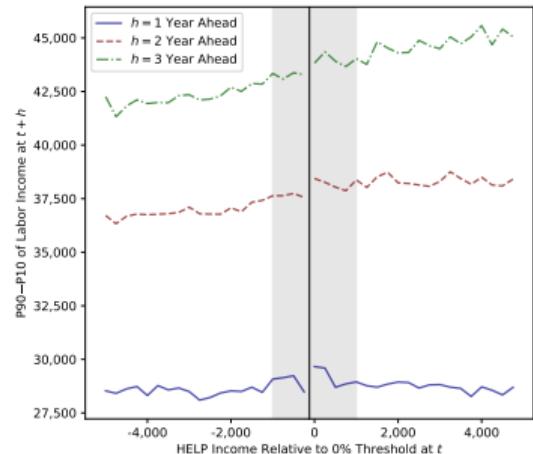
LIMITED EVIDENCE OF DYNAMIC COST TO BUNCHING



▶ Distribution

◀ Back

LITTLE DIFFERENCE IN DISTRIBUTION OF FUTURE INCOME



◀ Back

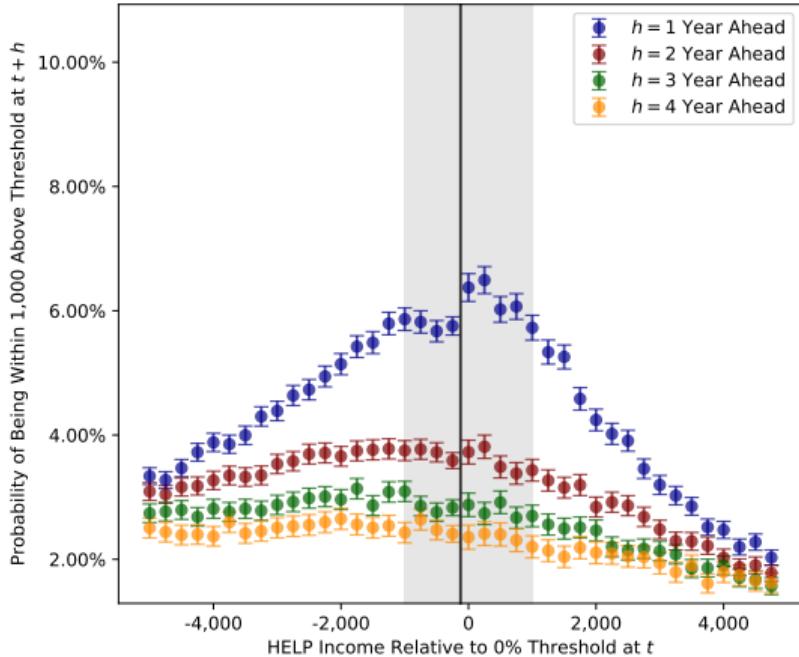
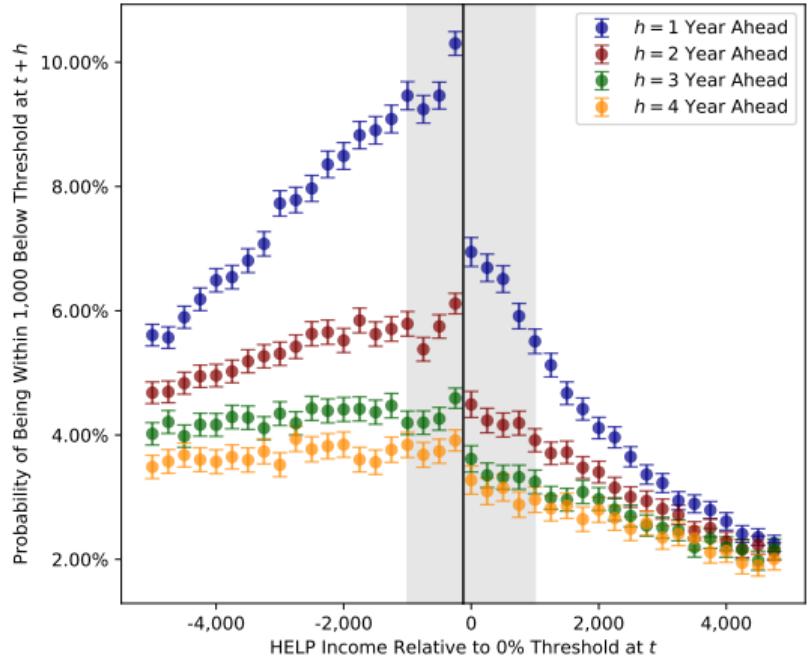
ADDITIONAL EMPIRICAL RESULTS

- ① **Persistence** of bunching below threshold lasts around three years 
- ② No discontinuity in probability of **switching occupations** around threshold 
- ③ Limited heterogeneity in bunching with household **demographics** 
 - Caveat: no extensive margin responses, which can vary across groups Saez et al. 2012
- ④ Limited evidence of bunching coming from **firm responses** (as in Chetty et al. 2011) 
- ⑤ Additional tests for **evasion**:
 - Bunching present in **salary and wages**, which is harder to misreport Slemrod 2019 
 - Minimal difference in bunching based on **filing type** 
 - Bunching declines by only 4% when dropping **self-employed** 
 - Borrowers are median income \Rightarrow less avoidance opportunities Slemrod-Yitzhaki 2002

 Back: Hours

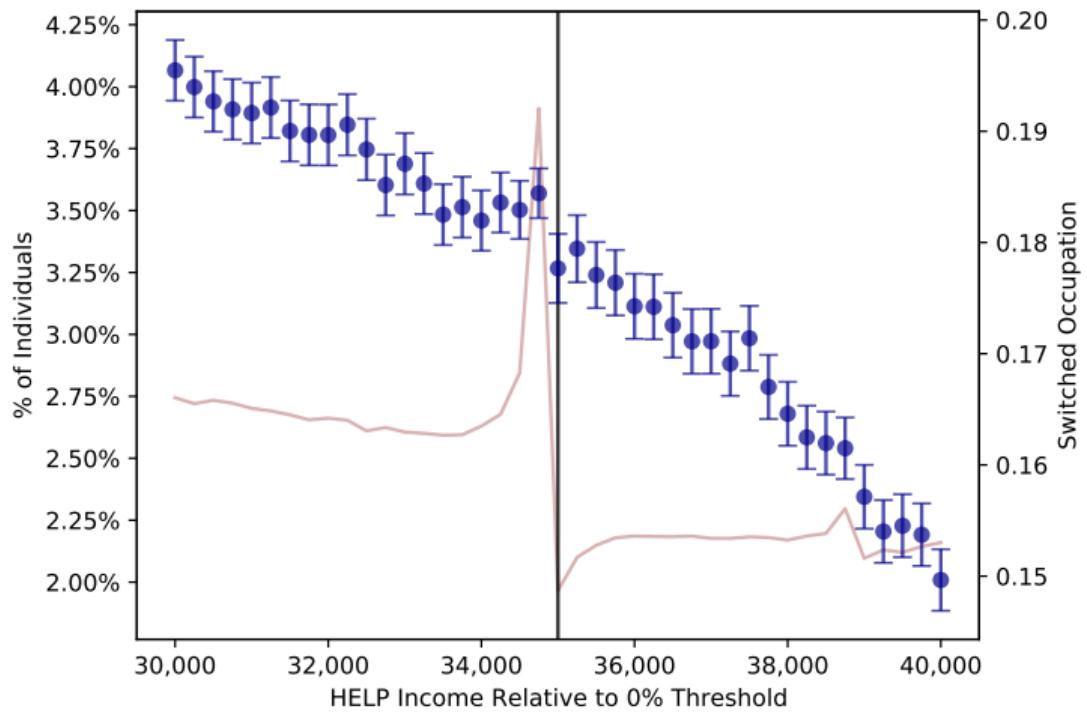
 Back: Summary

PERSISTENCE OF BUNCHING LASTS AROUND THREE YEARS



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No Discontinuity in the Probability of Switching Occupations



◀ Back

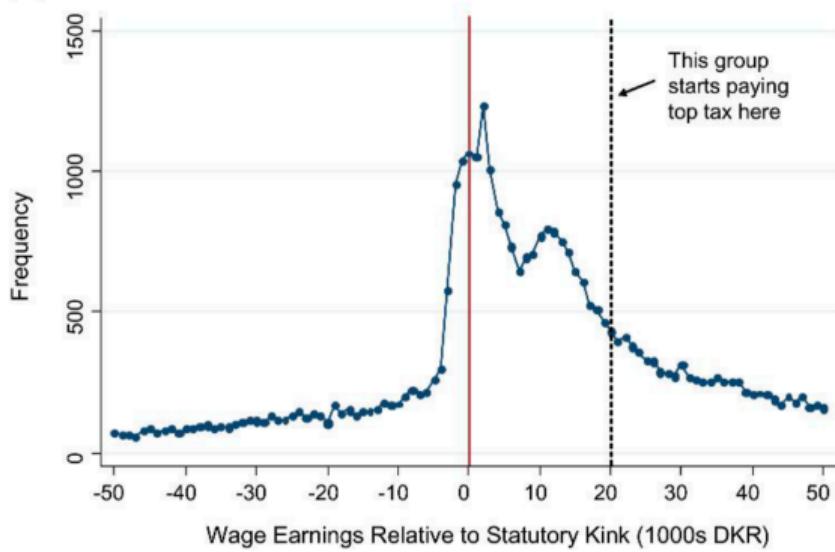
DEMOGRAPHIC HETEROGENEITY IN BUNCHING

| Sample | Estimated Bunching Statistic: b |
|----------------------------------|---------------------------------|
| Non-Electronic Filers | 0.086 |
| Electronic Filers | 0.082 |
| Wage-Earners | 0.081 |
| Entrepreneurs (Not Wage-Earners) | 0.117 |
| Females | 0.081 |
| Males | 0.083 |
| No Dependent Children | 0.086 |
| Has Dependent Children | 0.077 |
| No Spouse | 0.085 |
| Has Spouse | 0.081 |
| Full Sample | 0.084 |

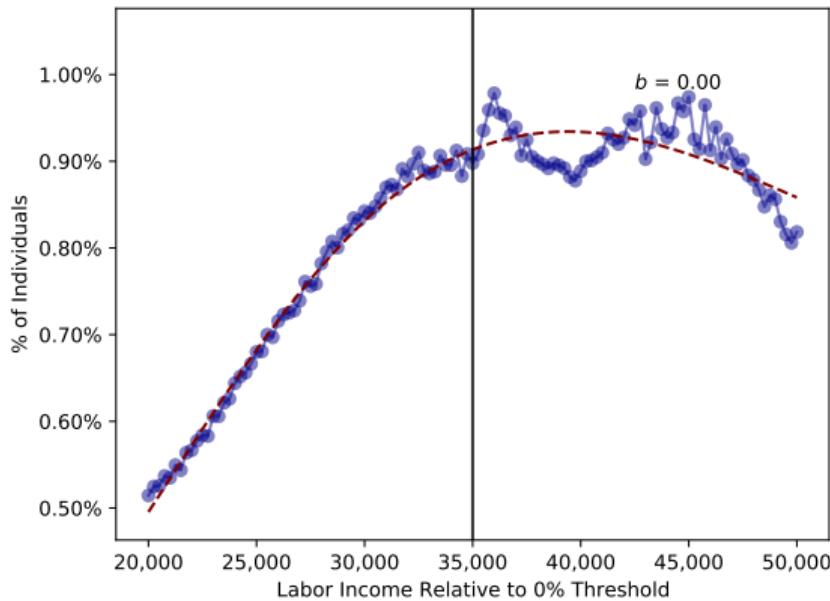
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CHETTY ET AL. (2011) TEST OF FIRM RESPONSES

Chetty et al: Teacher Wages



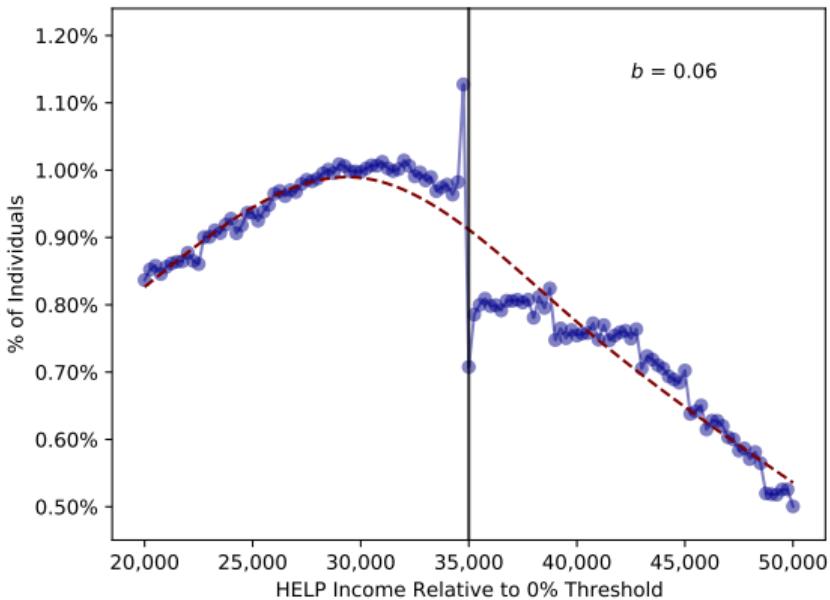
Borrower Labor Income



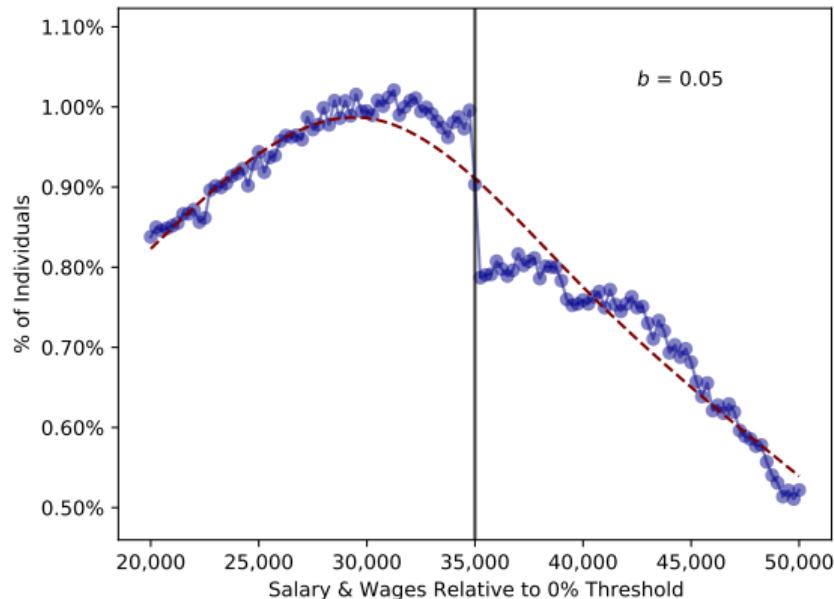
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BUNCHING IN DISTRIBUTION OF SALARY AND WAGES

HELP Income



Salary and Wages



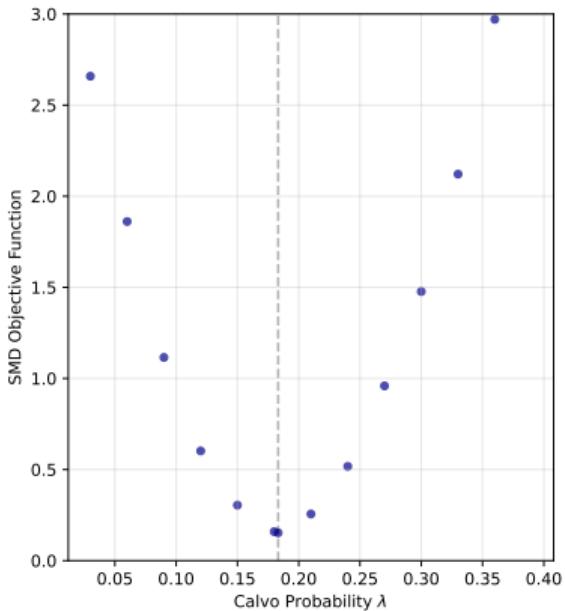
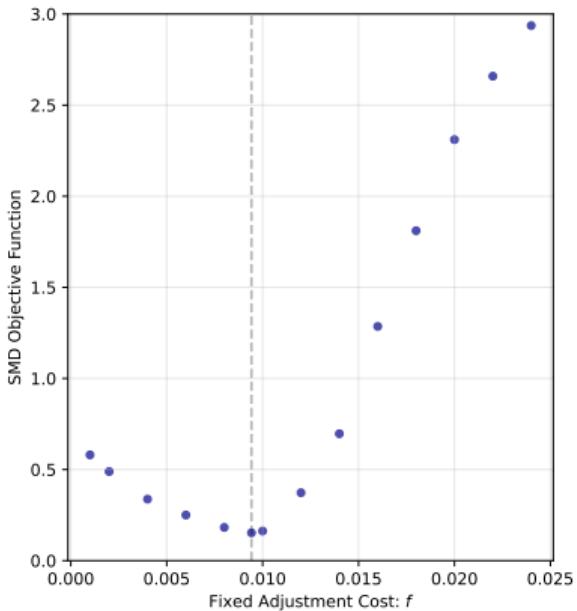
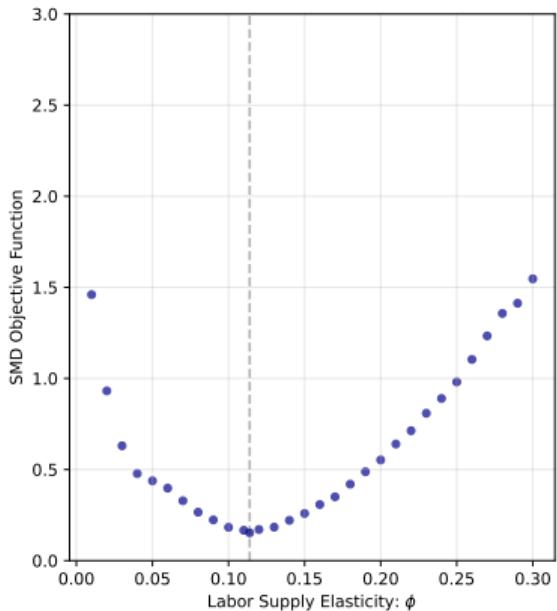
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ELASTICITY OF MOMENTS WITH RESPECT TO PARAMETERS

| | ϕ | f | λ |
|---------------------------|--------|-------|-----------|
| Mass Below 2004 Threshold | 0.08 | -0.16 | 0.21 |
| Mass Above 2004 Threshold | -0.03 | 0.09 | -0.13 |
| Mass Below 2005 Threshold | 0.12 | -0.16 | 0.28 |
| Mass Above 2005 Threshold | -0.04 | 0.09 | -0.19 |
| Ratio 2005 0% | 0.22 | -0.34 | 0.64 |
| Ratio 2005 0.5% | 0.13 | -0.12 | 0.16 |
| Ratio 2005 0%, Q1 Debt | 0.22 | -0.34 | 0.37 |
| Ratio 2005 0%, Q4 Debt | 0.20 | -0.33 | 0.82 |

◀ Back

SMM OBJECTIVE IS SMOOTH IN LABOR SUPPLY PARAMETERS



◀ Back

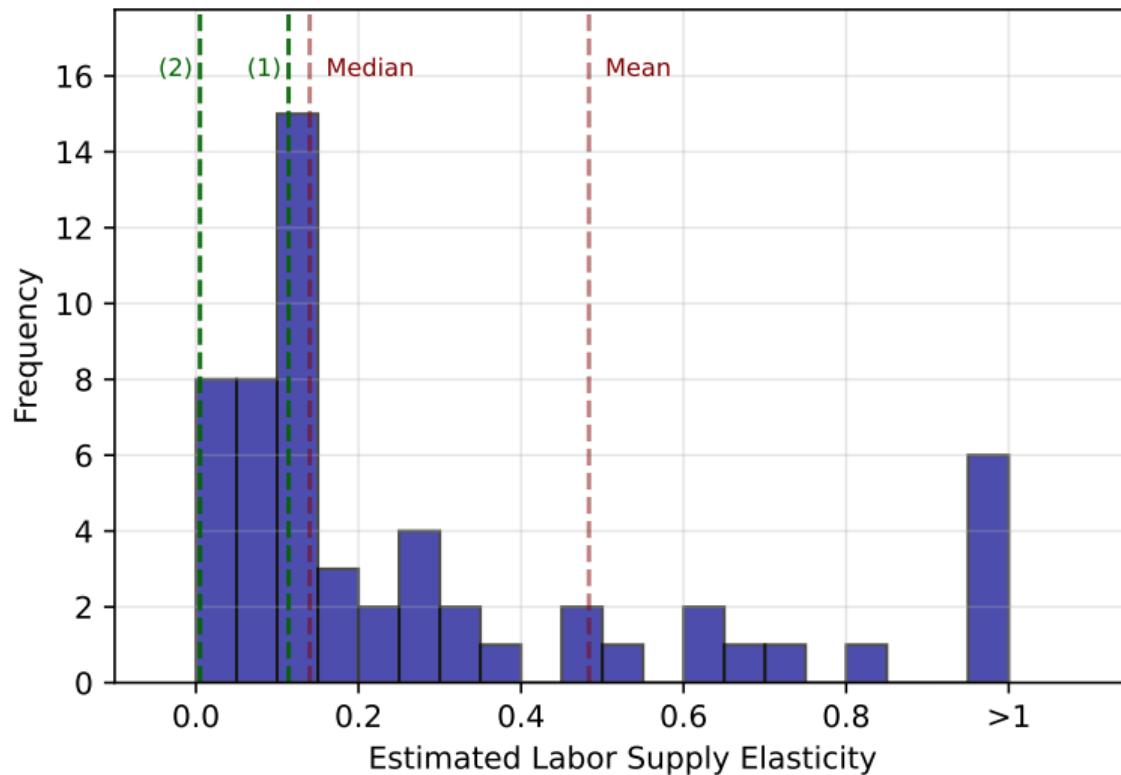
SECOND-STAGE SIMULATED MINIMUM DISTANCE: OTHER MOMENTS

$$\text{Parameters} = \left(\underbrace{\phi \ f \ \lambda \ \kappa \ \beta}_{\text{preferences}} \quad \underbrace{\delta_0 \ \delta_1 \ \delta_2 \ \delta_0^E \ \delta_1^E}_{\text{wage profile}} \quad \underbrace{\rho \ \sigma_\nu \ \sigma_\epsilon \ \sigma_i}_{\text{wage risk}} \right)$$

- Age profiles of salary & wages \Rightarrow wage profile parameters
- Moments in Guvenen et al. 2022 \Rightarrow wage risk parameters
- Average capital income at ages 40-44 \Rightarrow β
- Average labor supply \Rightarrow κ

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COMPARISON WITH EXISTING LITERATURE ON LABOR SUPPLY (1/2)



Source: intensive-margin Hicks and Frisch elasticities in Keane (2011) and Chetty (2012)

COMPARISON WITH EXISTING LITERATURE ON LABOR SUPPLY (2/2)

Reasons why frictionless elasticity may be smaller/frictions larger:

- ① Different **sample** of college graduates: less flexibility and further from $y_t = w_t l_t$
- ② Elasticity is **local** to threshold: no high-income individuals Gruber-Saez 2002
- ③ Bunching does not identify **extensive** margin responses Saez et al. 2012

Contributions:

- ① **Empirical** characterization of responses to income-contingent repayment
 - ℓ_t of indebted households responds to liquidity not wealth, like c_t Ganong-Noel 2020
- ② **Dynamic** model of labor supply with time- and state-dependent adjustment
 - ✓ First paper (to my knowledge) to explicitly estimate different types of frictions

◀ Back

FULL ESTIMATION RESULTS

| Parameter | | Estimation | | | | | | |
|--|-------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| | | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Labor supply elasticity | ϕ | 0.114 (.004) | 0.005 (.000) | 0.188 (.003) | 0.053 (.002) | 0.082 (.002) | 0.111 (.004) | 0.067 (.002) |
| Adjustment cost | f | \$377 (\$13) | \$0 . . | \$2278 (\$21) | \$0 . . | \$762 (\$10) | \$513 (\$19) | \$848 (\$11) |
| Calvo probability | λ | 0.183 (.003) | 1 . . | 1 . . | 0.147 (.002) | 0.346 (.009) | 0.191 (.003) | 0.266 (.005) |
| Scaling parameter | κ | 0.560 (.007) | 0.030 (.003) | 0.059 (.014) | 0.510 (.012) | 1.242 (.116) | 0.593 (.001) | 0.448 (.001) |
| Time discount factor | β | 0.973 (.001) | 0.996 (.000) | 0.972 (.001) | 0.944 (.001) | 0.951 (.001) | 0.951 (.001) | 0.946 (.001) |
| Wage profile parameters | δ_0 | 8.922 (.009) | 9.862 (.002) | 8.680 (.006) | 9.389 (.007) | 9.197 (.007) | 9.143 (.008) | 9.211 (.008) |
| | δ_1 | 0.073 (.000) | 0.111 (.000) | 0.073 (.000) | 0.063 (.000) | 0.070 (.000) | 0.075 (.000) | 0.074 (.000) |
| | δ_2 | -0.001 (.000) | -0.002 (.000) | -0.001 (.000) | -0.001 (.000) | -0.001 (.000) | -0.001 (.000) | -0.001 (.000) |
| | δ_0^E | -0.487 (.002) | -0.294 (.000) | -0.450 (.001) | -0.530 (.002) | -0.480 (.002) | -0.478 (.002) | -0.505 (.002) |
| | δ_1^E | 0.020 (.000) | 0.032 (.000) | 0.018 (.000) | 0.021 (.000) | 0.018 (.000) | 0.020 (.000) | 0.021 (.000) |
| Persistence of permanent shock | ρ | 0.930 (.000) | 0.914 (.000) | 0.943 (.000) | 0.922 (.000) | 0.889 (.000) | 0.907 (.001) | 0.931 (.001) |
| Standard deviation of permanent shock | σ_ν | 0.236 (.000) | 0.076 (.000) | 0.196 (.000) | 0.268 (.000) | 0.288 (.000) | 0.275 (.001) | 0.246 (.001) |
| Standard deviation of transitory shock | σ_ϵ | 0.130 (.000) | 0.504 (.000) | 0.168 (.000) | 0.077 (.002) | 0.064 (.002) | 0.080 (.002) | 0.116 (.001) |
| Standard deviation of individual FE | σ_i | 0.599 (.003) | 0.101 (.001) | 0.541 (.003) | 0.654 (.003) | 0.625 (.003) | 0.612 (.003) | 0.632 (.003) |
| Learning-by-doing parameter | α | 0 | 0 | 0 | 0 | 0.24 | 0 | 0 |
| Adjustment cost function | | Fixed No | Fixed No | Fixed No | Fixed No | Fixed No | Linear No | Fixed Yes |
| Misperception of debt payoff | | | | | | | | |

◀ Back: Estimation

◀ Back: Additional

MODEL FIT: OTHER TARGET MOMENTS

| Estimation Target | Data | Model |
|--|----------|----------|
| Average Labor Income | \$42,639 | \$45,582 |
| Cross-Sectional Variance of Log Labor Income at Age 22 | 0.453 | 0.462 |
| Cross-Sectional Variance of Log Labor Income at Age 32 | 0.555 | 0.491 |
| Cross-Sectional Variance of Log Labor Income at Age 42 | 0.577 | 0.525 |
| Cross-Sectional Variance of Log Labor Income at Age 52 | 0.539 | 0.580 |
| Cross-Sectional Variance of Log Labor Income at Age 62 | 0.608 | 0.657 |
| Linear Age Profile Term | 0.077 | 0.080 |
| Quadratic Age Profile Term | -0.001 | -0.001 |
| Education Income Premium Constant | -0.574 | -0.554 |
| Education Income Premium Slope | 0.023 | 0.023 |
| 10th Percentile of 1-Year Labor Income Growth | -0.387 | -0.392 |
| 10th Percentile of 5-Year Labor Income Growth | -0.667 | -0.705 |
| 90th Percentile of 1-Year Labor Income Growth | 0.415 | 0.393 |
| 90th Percentile of 5-Year Labor Income Growth | 0.698 | 0.710 |
| Average Labor Supply | 1.000 | 0.963 |
| Average Capital Income between Ages 40 and 44 | \$1,338 | \$1,332 |

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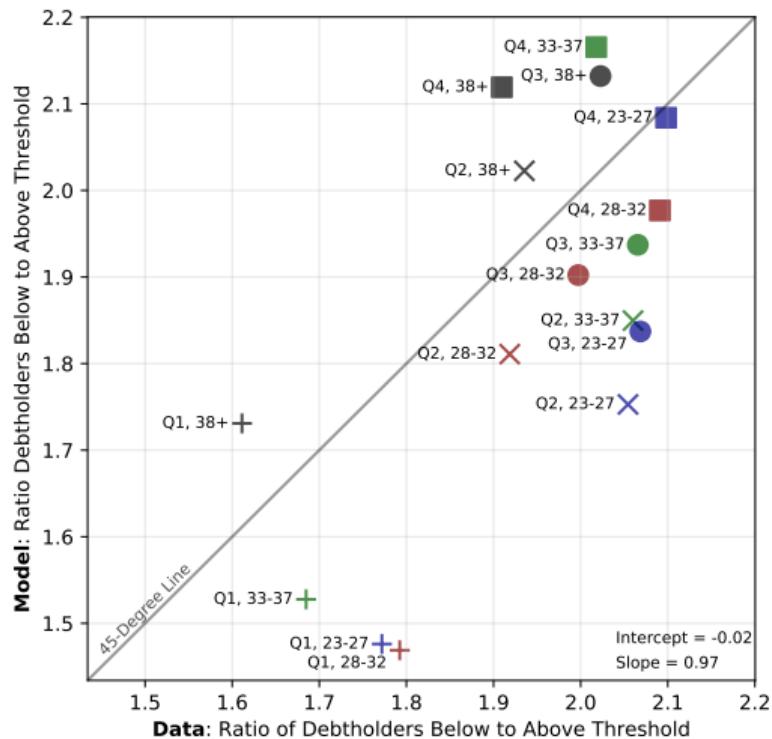
ADDITIONAL MODEL RESULTS: POSITIVE

- ① **Robustness:** $\hat{\phi} = 0.111$ with linear adjustment costs (vs. 0.114) 
- ② **Validation** of baseline model on nontargeted moments: 
 - Matches heterogeneity in bunching by debt and age, while LBD model cannot 
 - Replicates bunching at changes in marginal income tax rates
- ③ **P(Repayment)** matters:
 - Counterfactual with indefinite repayment \Rightarrow bunching $\uparrow 70\%$ 
 - Ignoring dynamic incentives $\Rightarrow \hat{\phi} \downarrow 40\%$ 
- ④ **Liquidity** matters: risk-free borrowing up to natural limit \Rightarrow bunching $\downarrow 90\%$ 
- ⑤ **Laffer curve**: revenue-maximizing linear tax rate close to static model 

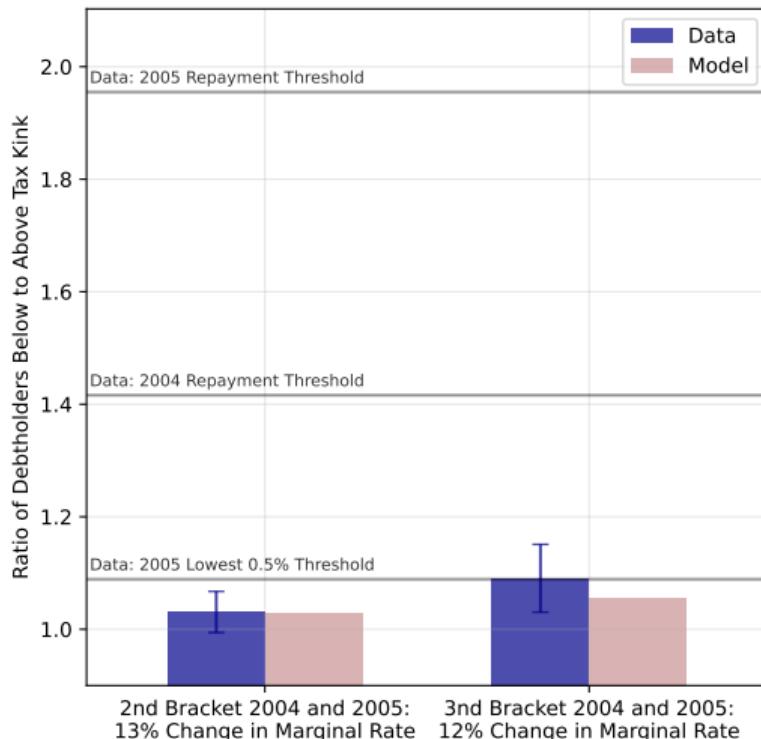
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VALIDATION OF BASELINE MODEL ON NONTARGETED BUNCHING

Heterogeneity by Debt and Age



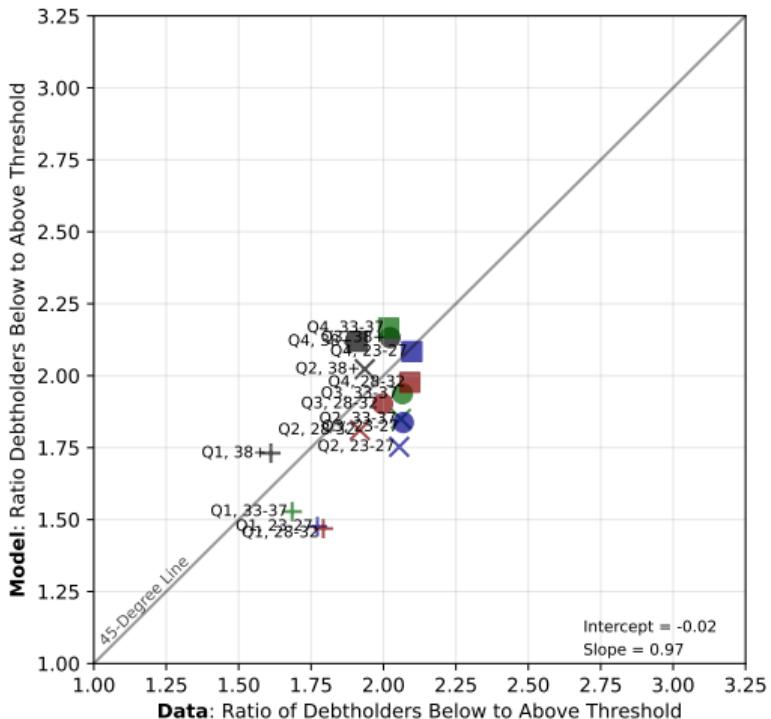
Bunching at Changes in Tax Rates



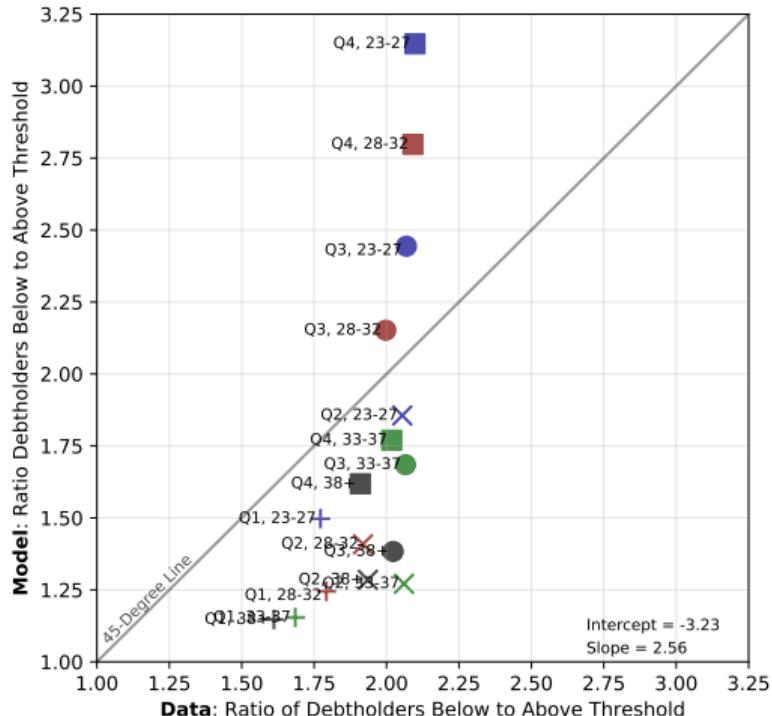
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LEARNING-BY-DOING MODEL FITS WORSE THAN BASELINE MODEL

Baseline Model

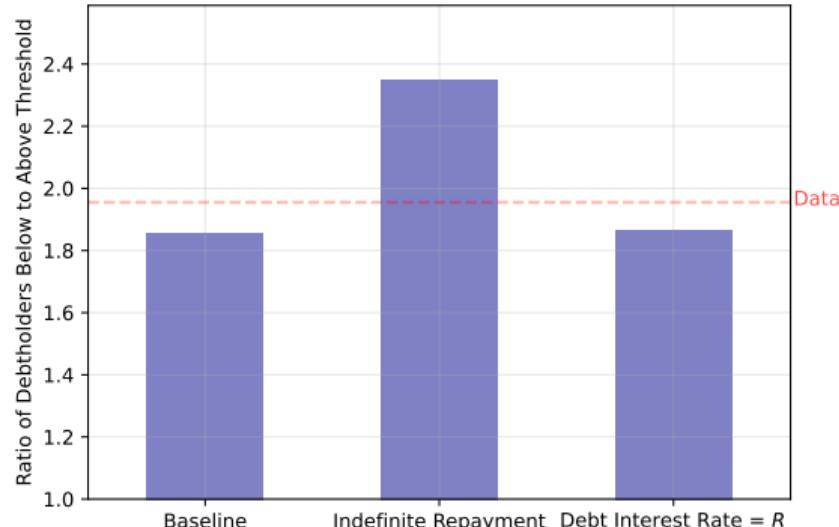
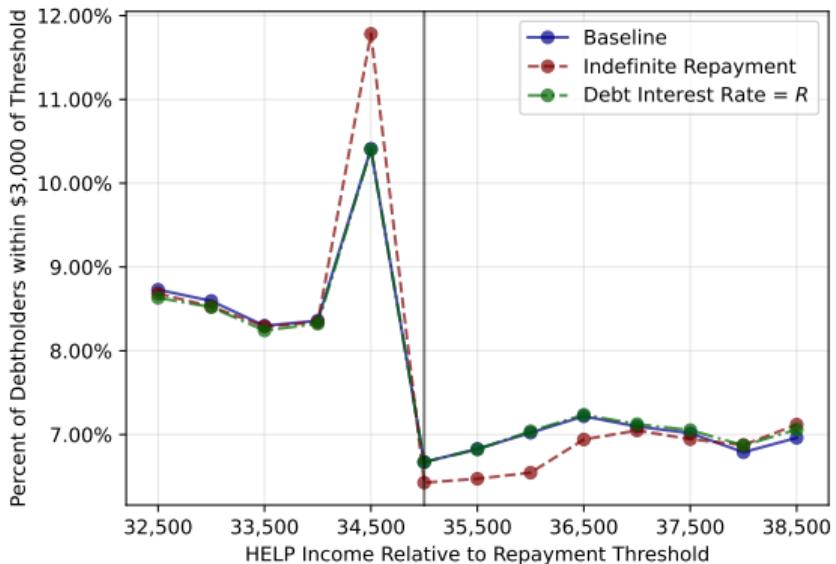


Learning-by-Doing Model



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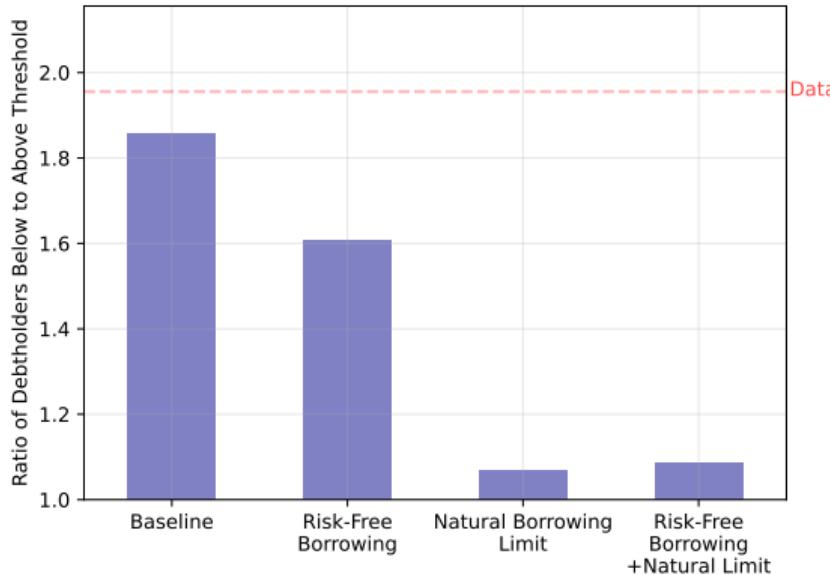
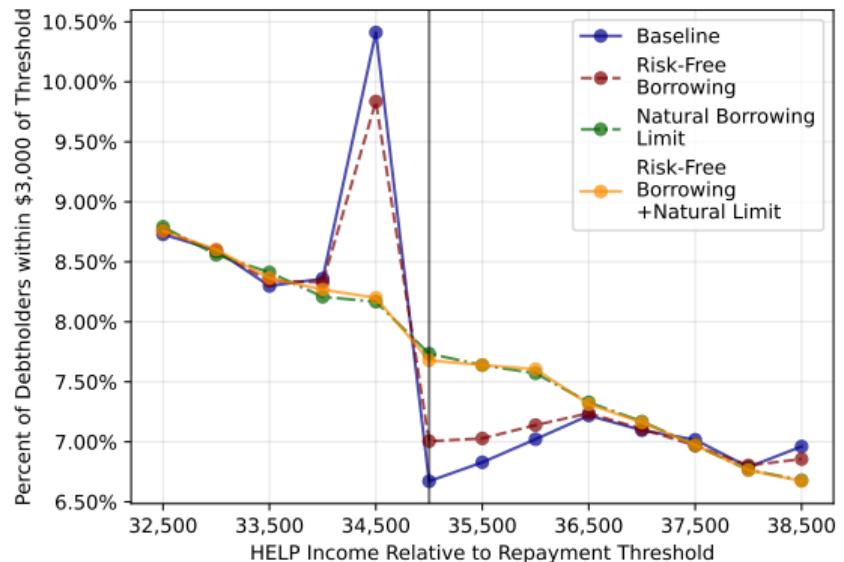
DYNAMICS: BUNCHING DEPENDS ON PROBABILITY OF REPAYMENT



- **Data:** bunching increases with debt and decreases with lifetime income
- **Model:** no repayment limit $\Rightarrow \uparrow$ PDV of repayment reduction \Rightarrow bunching $\uparrow 70\%$

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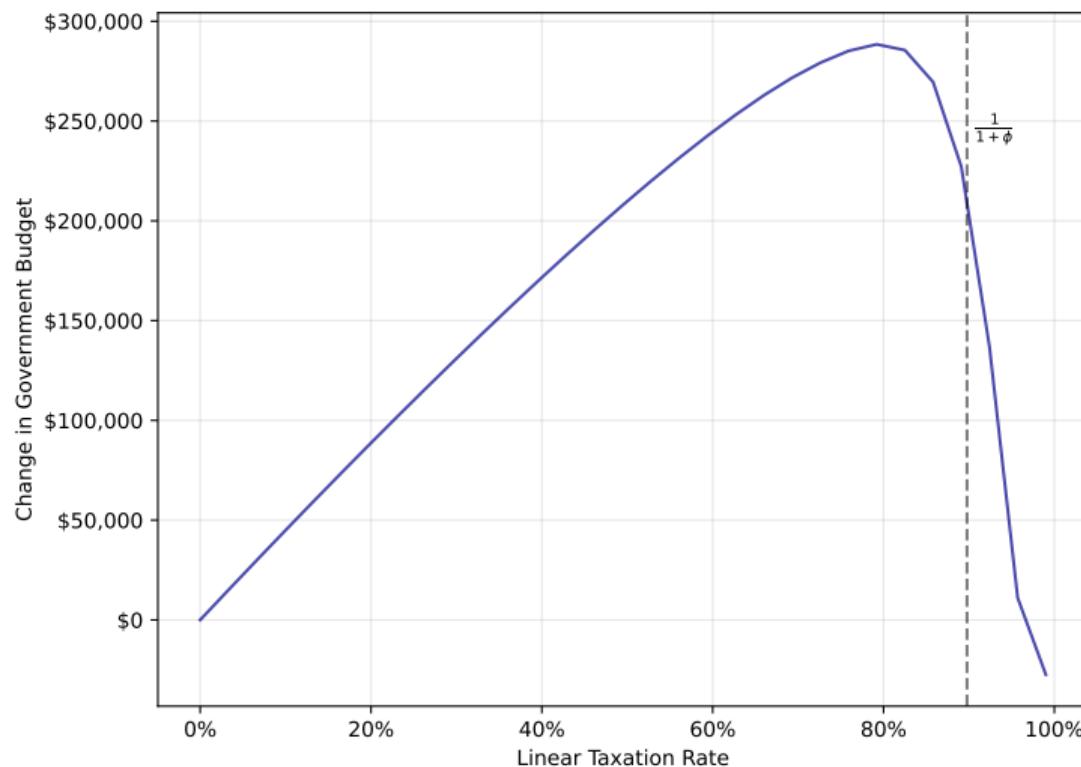
LIQUIDITY: BORROWING CONSTRAINTS AMPLIFY RESPONSES



- **Data:** bunching \downarrow in wealth and \uparrow in liquidity demands
- **Model:** freely borrow at $r_f \Rightarrow \downarrow$ value of repayment reduction \Rightarrow bunching \downarrow **90%**

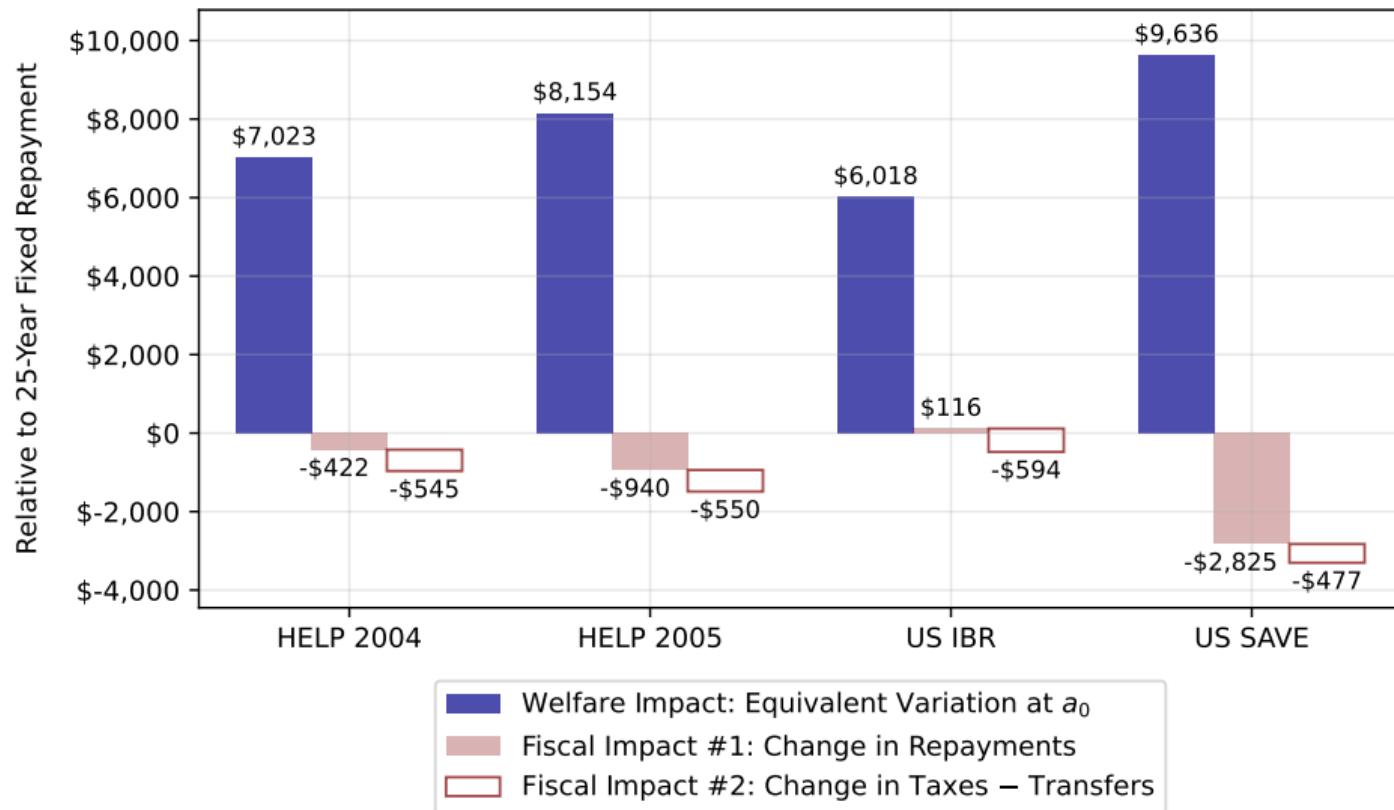
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LAFFER CURVE FROM LINEAR TAXATION

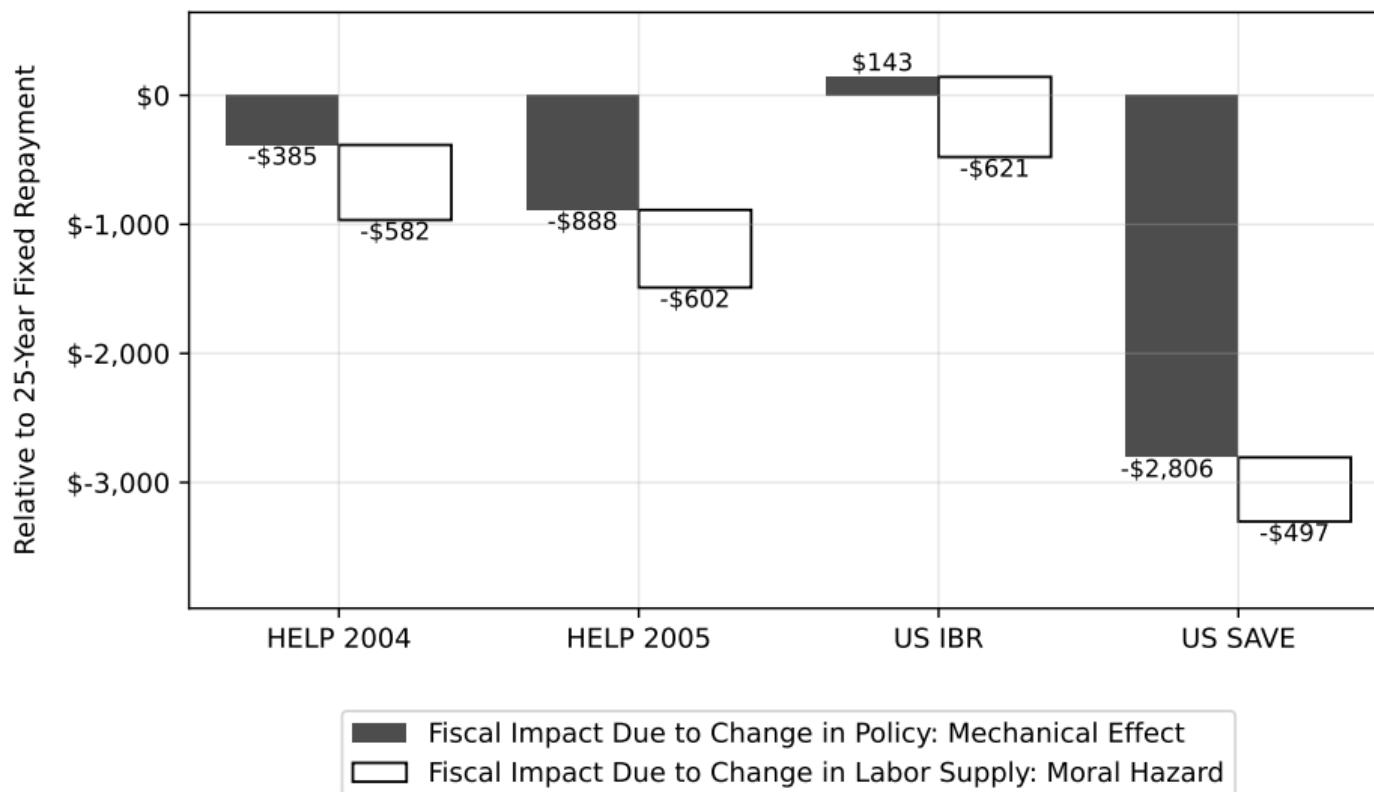


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EXISTING INCOME-CONTINGENT LOANS VS. FIXED REPAYMENT

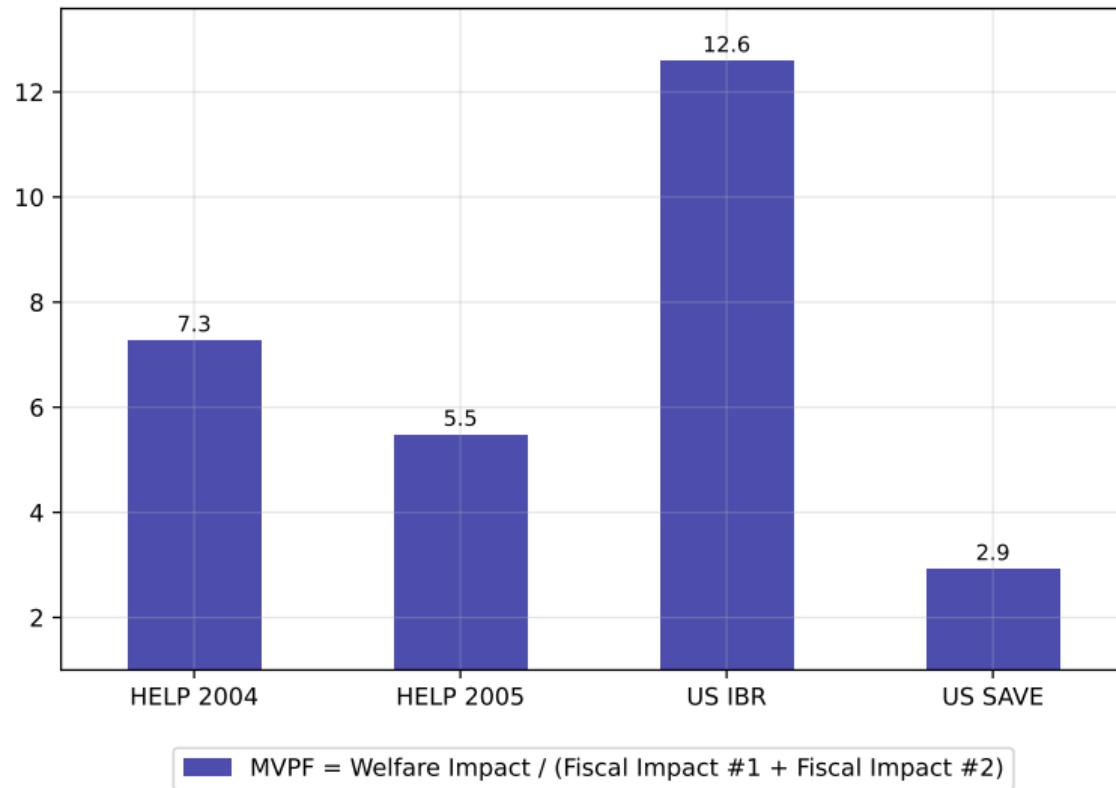


DECOMPOSITION OF FISCAL IMPACT: ENDOGENOUS LABOR SUPPLY



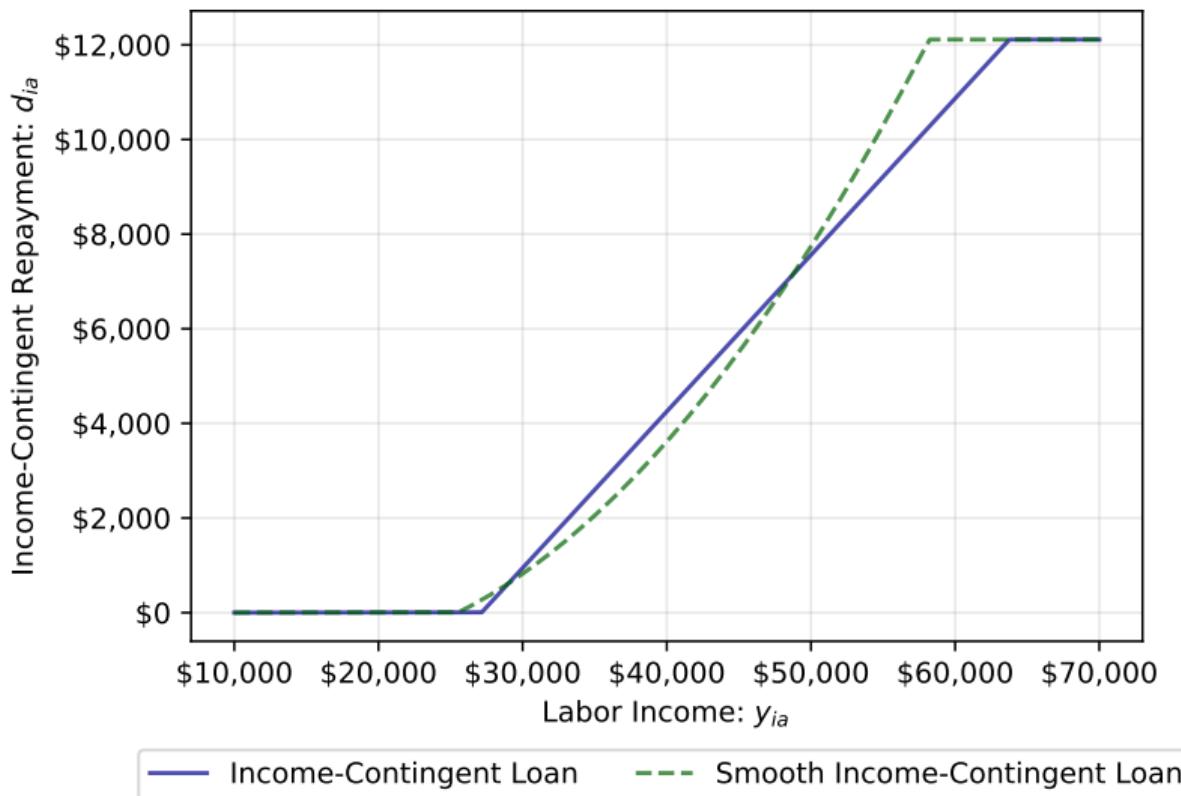
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MARGINAL VALUE OF PUBLIC FUNDS



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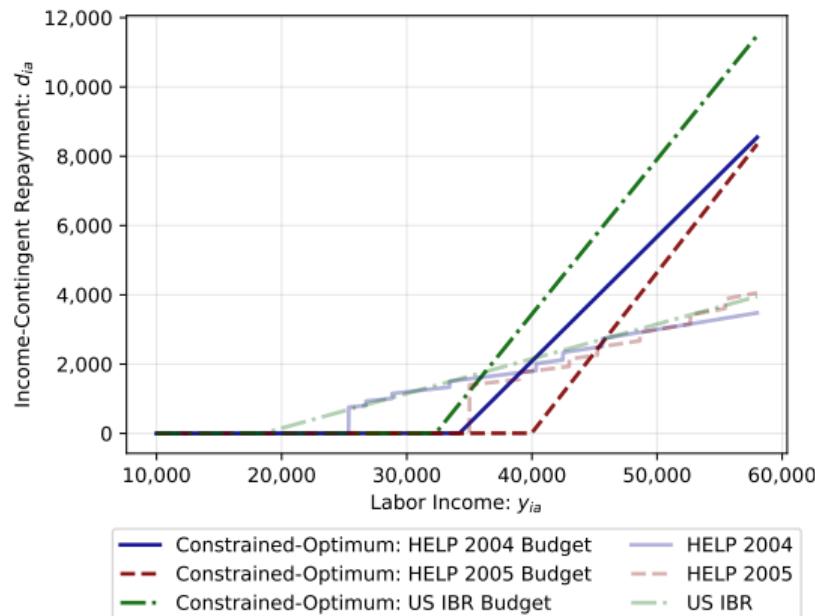
SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM: QUADRATIC



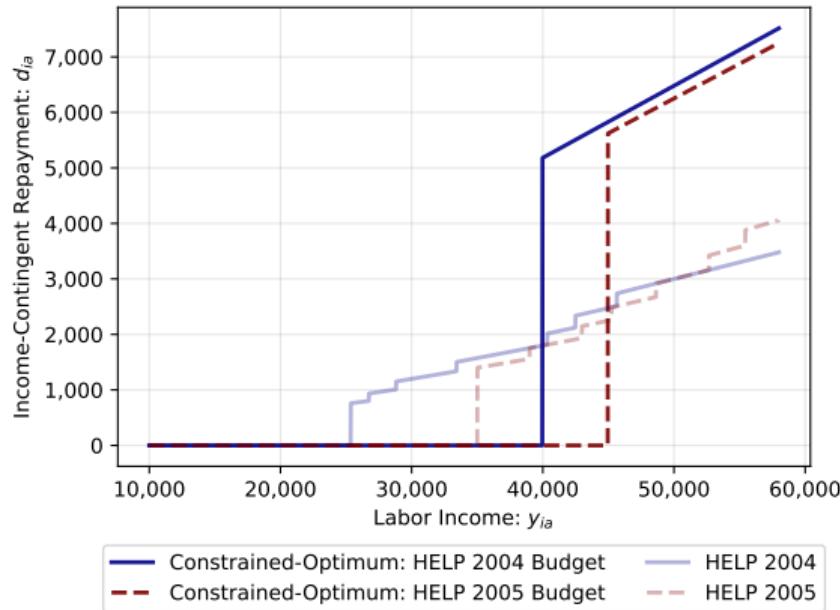
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OPTIMAL VERSUS EXISTING INCOME-CONTINGENT LOANS

Change in Marginal Rate

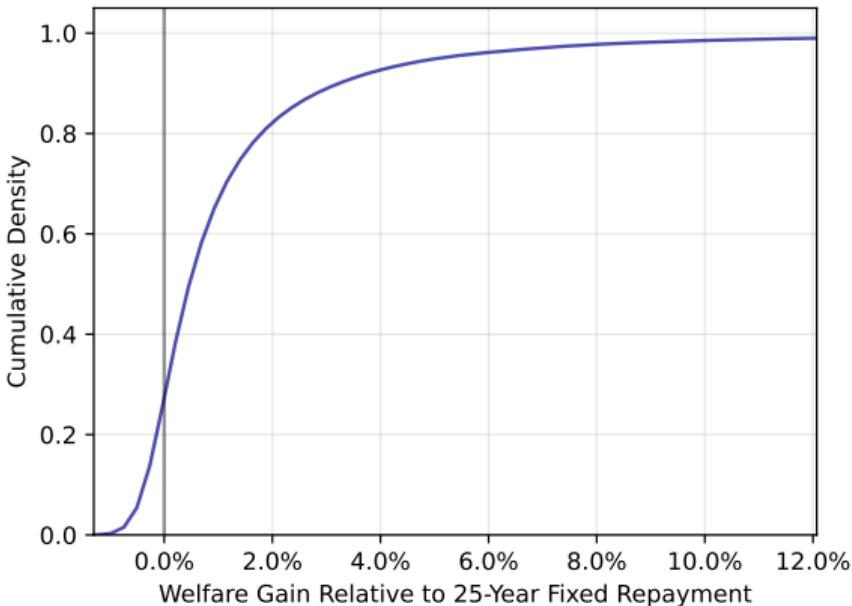
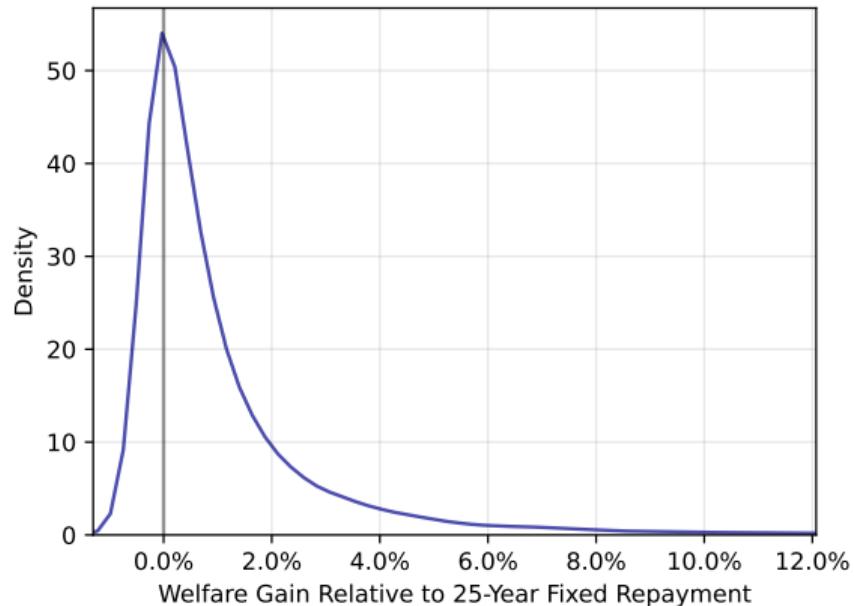


Change in Average Rate



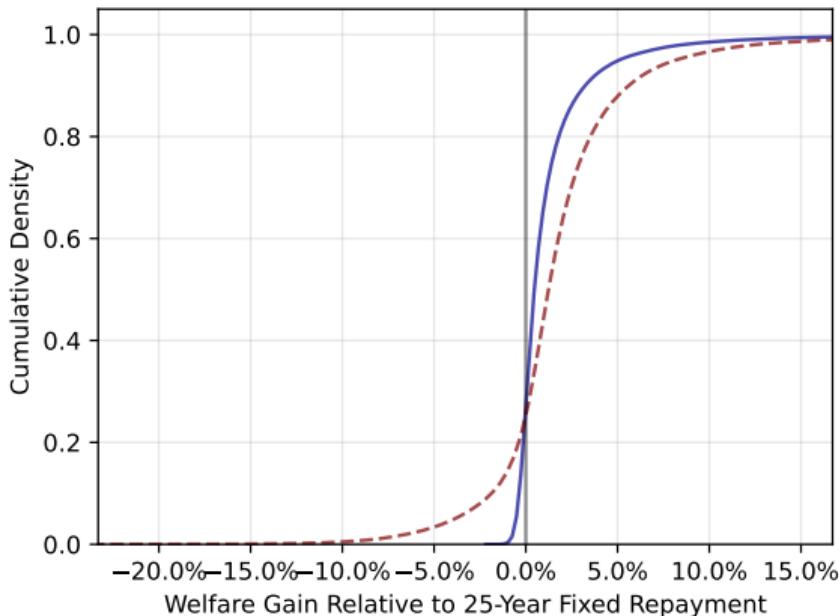
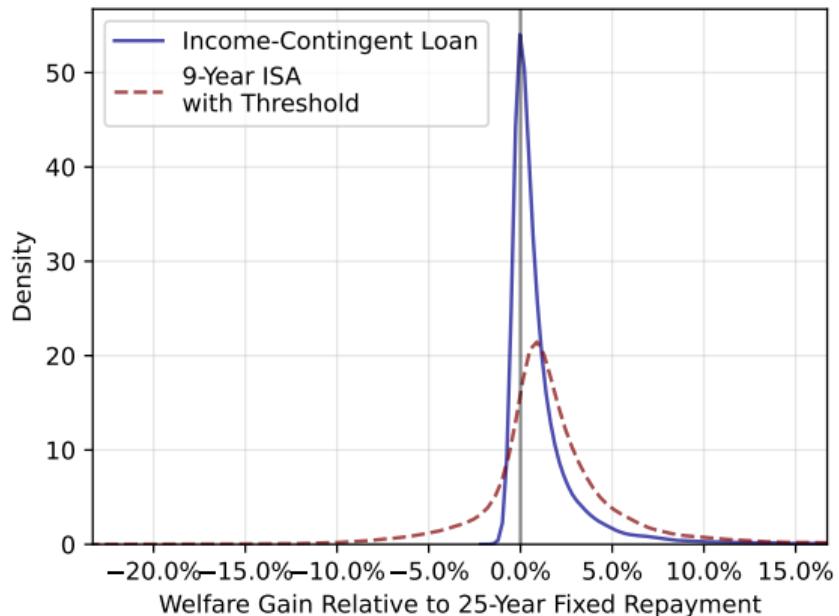
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DISTRIBUTION OF INITIAL WELFARE GAINS: ICL



- Only **1.2%** of borrowers have welfare loss above 0.5%

DISTRIBUTION OF INITIAL WELFARE GAINS: ICL vs. EQUITY

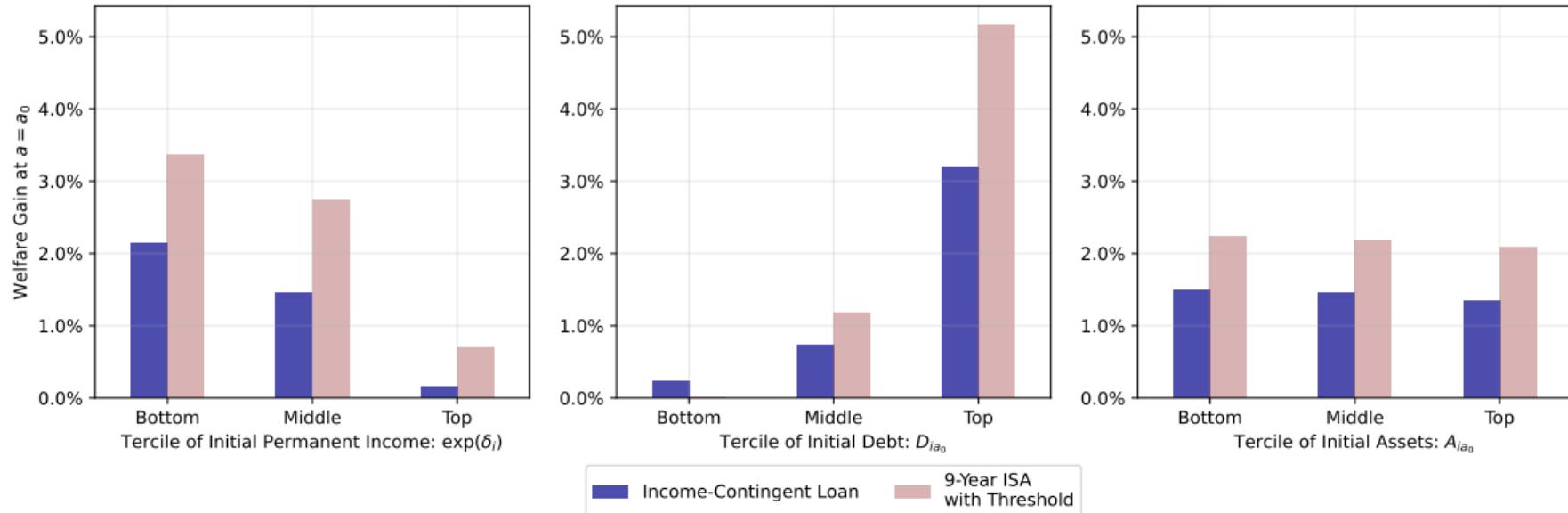


- **18%** of borrowers have welfare loss above 0.5% for equity vs. **1.2%** for ICL

▶ Heterogeneity by Initial States

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HETEROGENEITY IN WELFARE GAINS ACROSS INITIAL STATES



▶ Losers under ICL

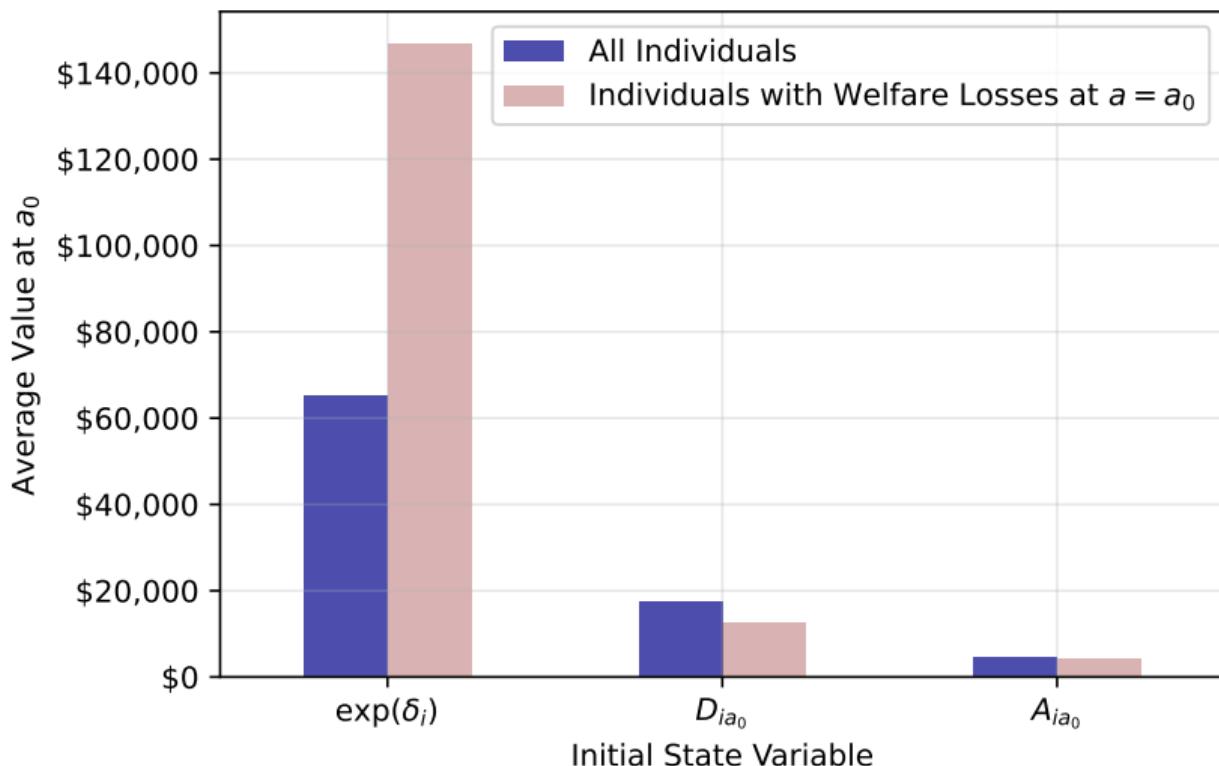
▶ Heterogeneity by Age

▶ Heterogeneity by Initial Debt

◀ Back: ICL Gain

◀ Back: Contracts

INDIVIDUALS WITH INITIAL WELFARE LOSSES: ICL



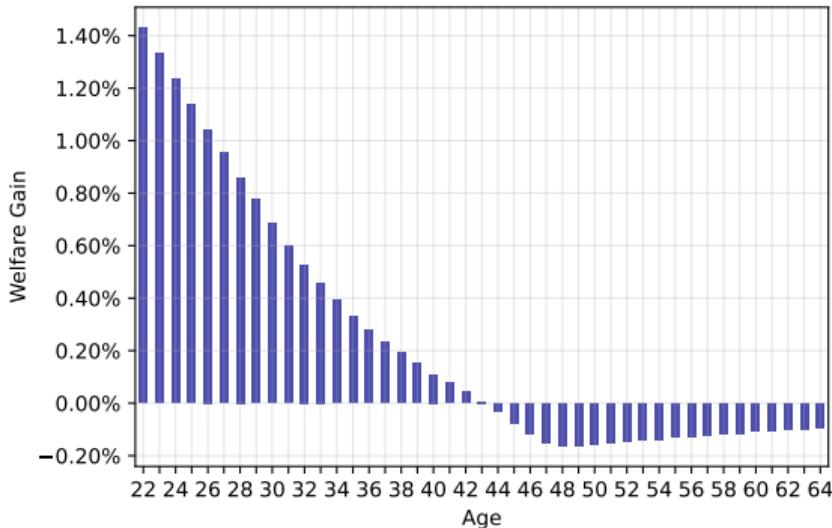
► Heterogeneity by Age

◀ Back: ICL Gain

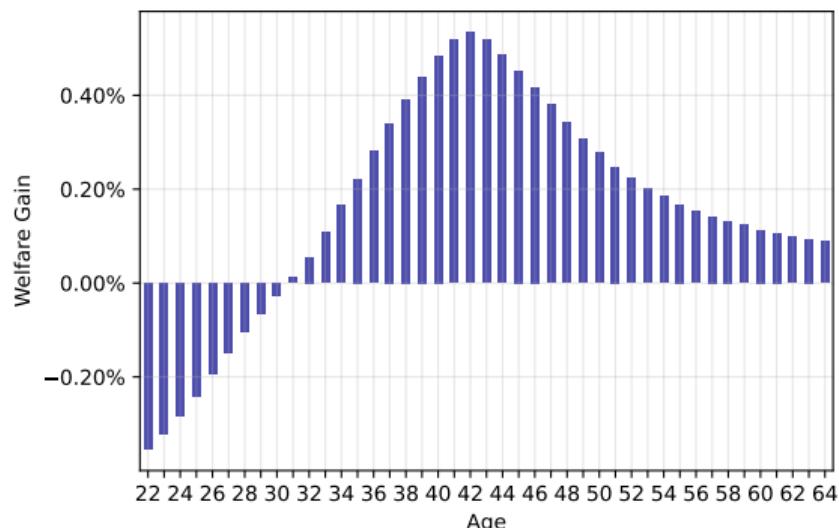
◀ Back: Contracts

WELFARE GAINS BY AGE

ICL vs. 25-Year Fixed



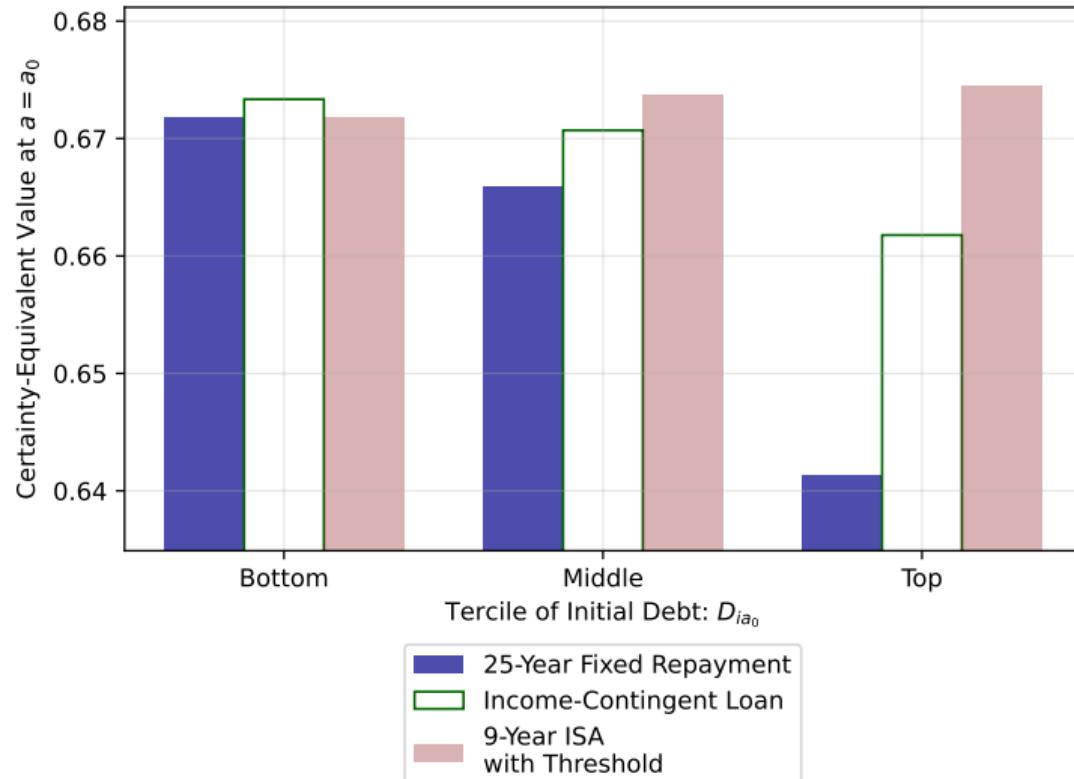
ICL + 20-Year Forgiveness vs. ICL



◀ Back: ICL Gain

◀ Back: Contracts

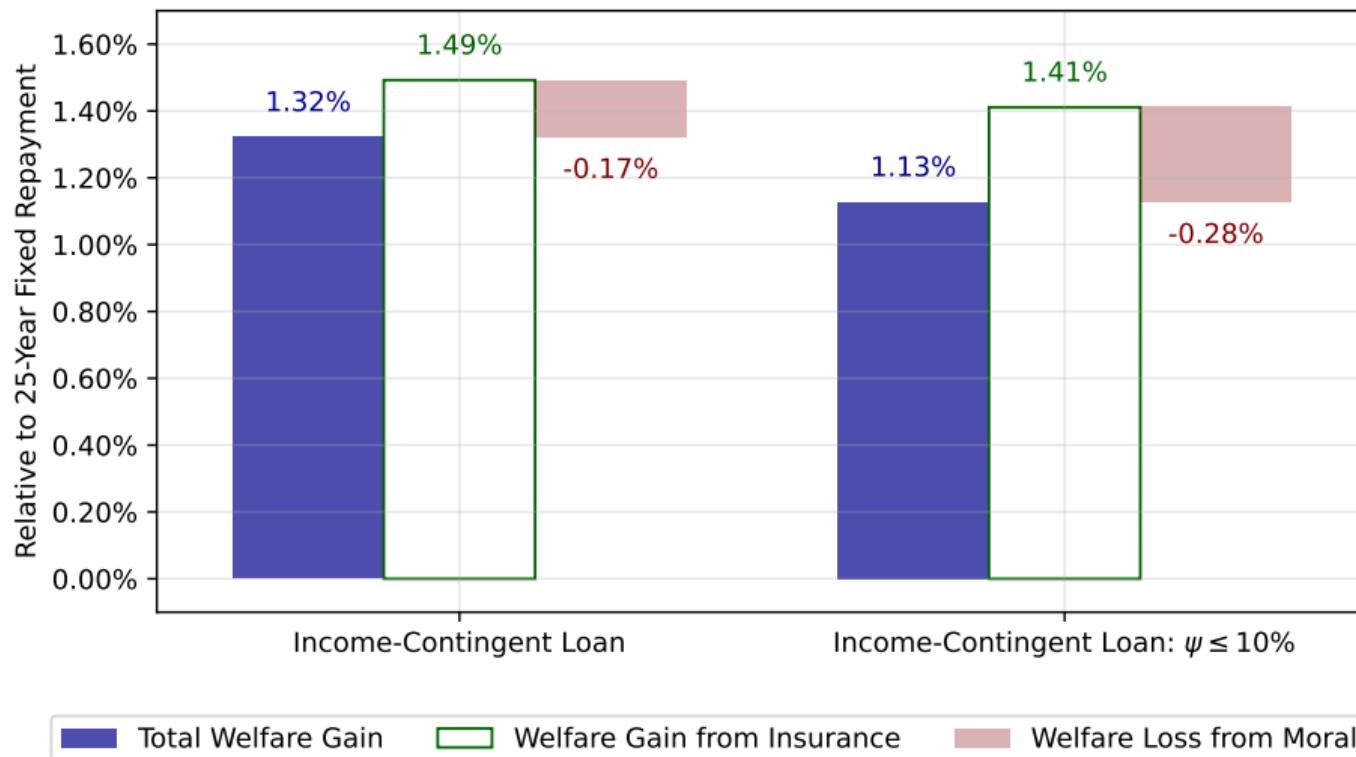
CERTAINTY-EQUIVALENTS ACROSS INITIAL DEBT



◀ Back: ICL Gain

◀ Back: Contracts

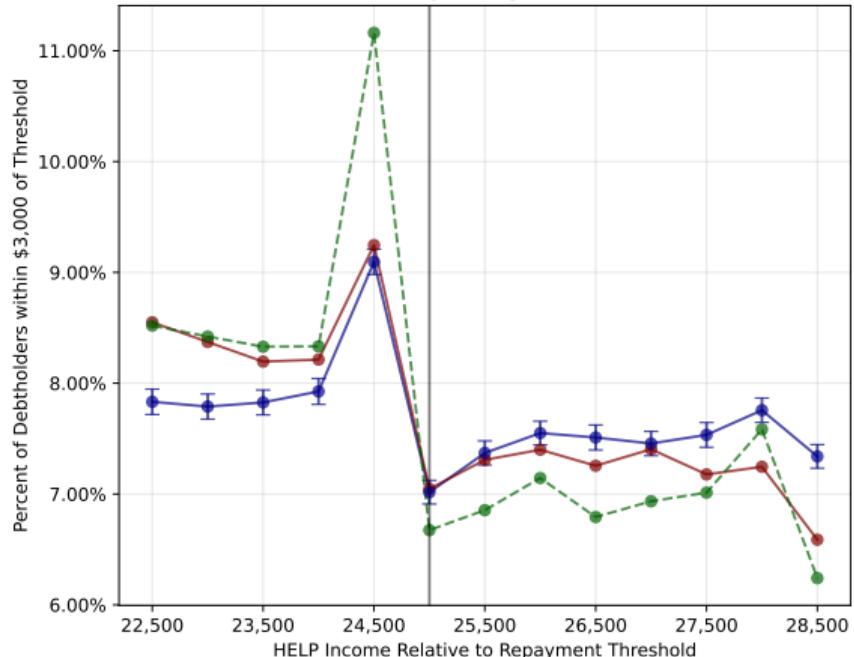
CONSTRAINING REPAYMENT RATE REDUCES WELFARE GAINS



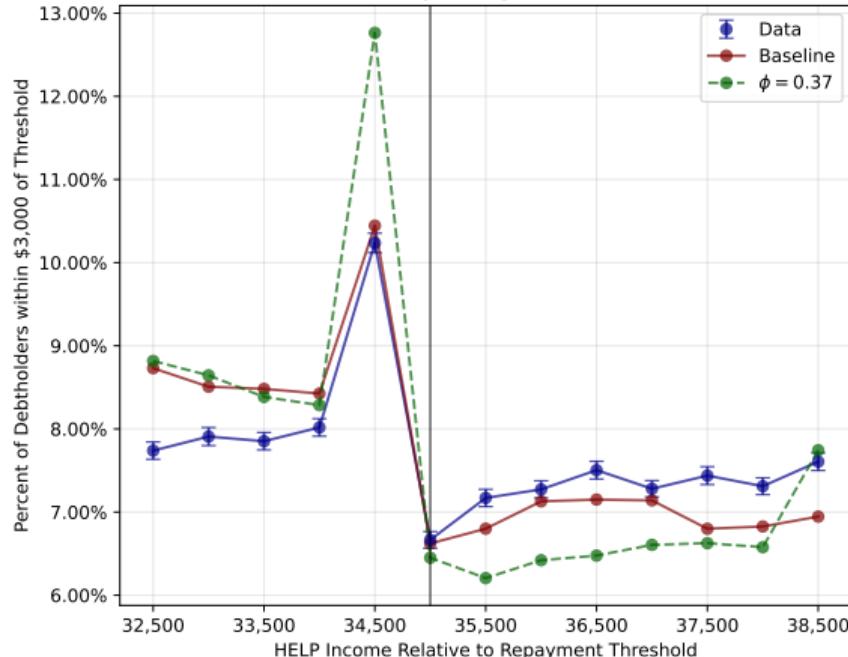
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FIT OF MODEL IN WHICH FIXED REPAYMENT IS OPTIMAL

Before Policy Change: 2002-2004



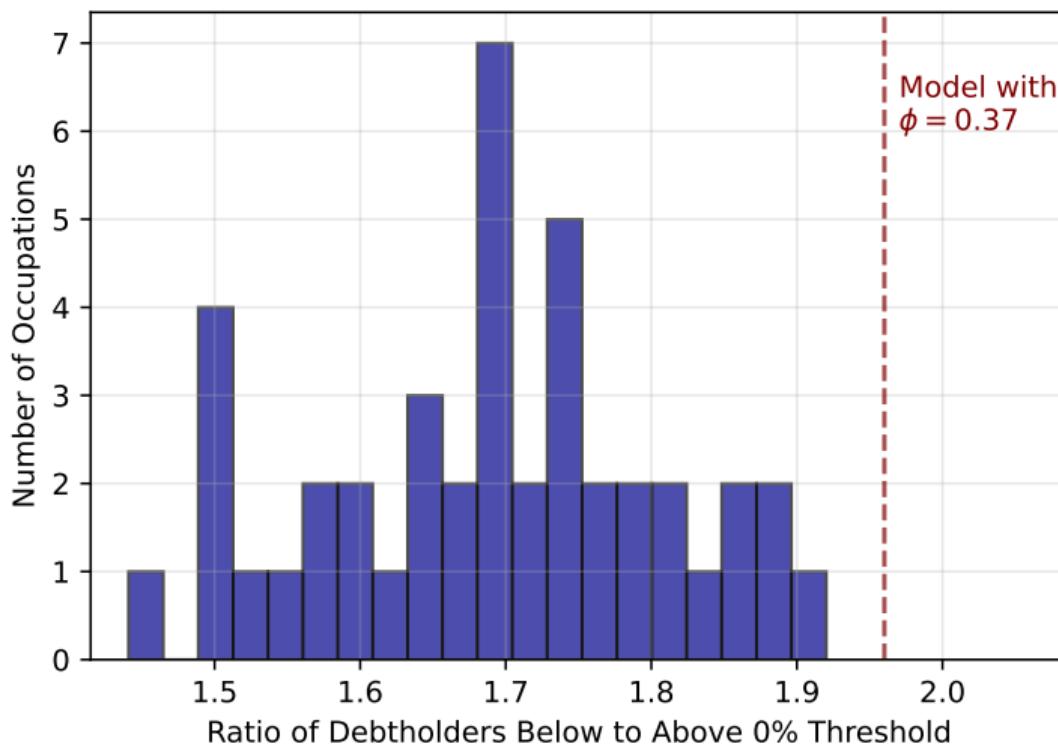
After Policy Change: 2005-2007



▶ Occupations

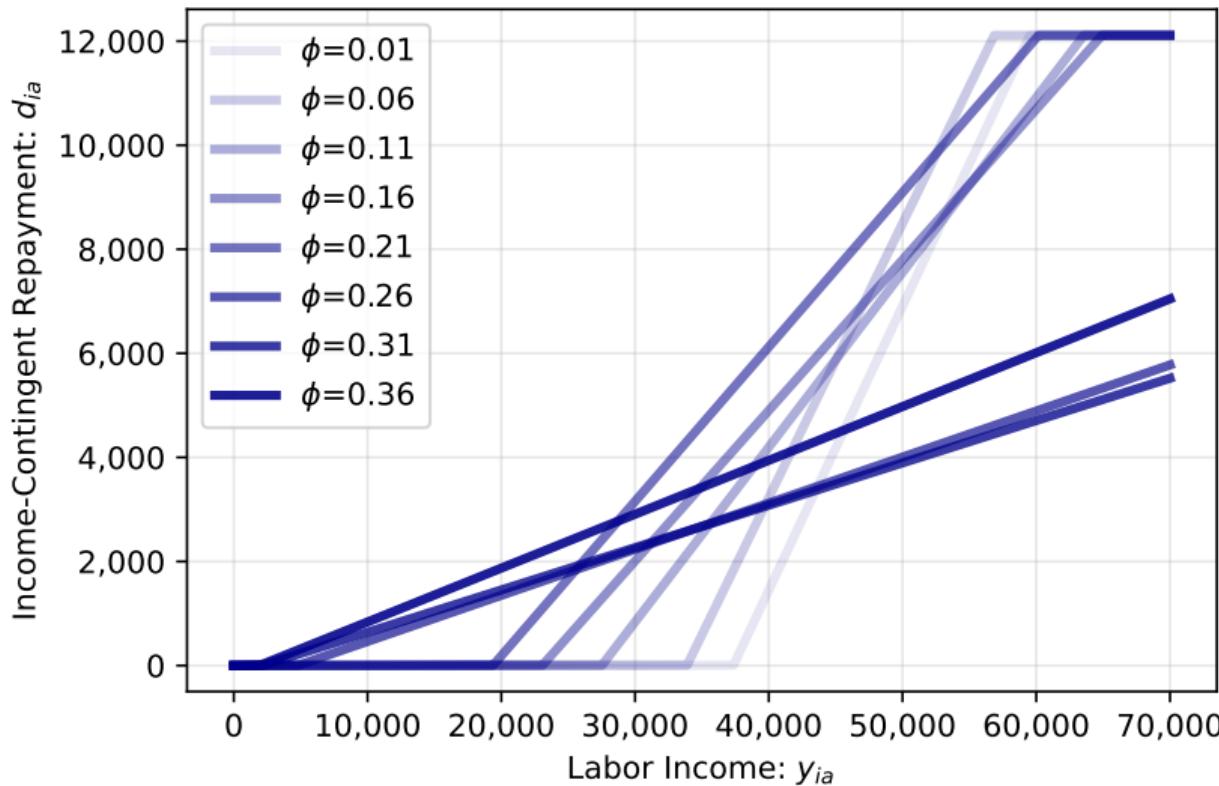
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BUNCHING WHEN FIXED REPAYMENT IS OPTIMAL vs. OCCUPATIONS



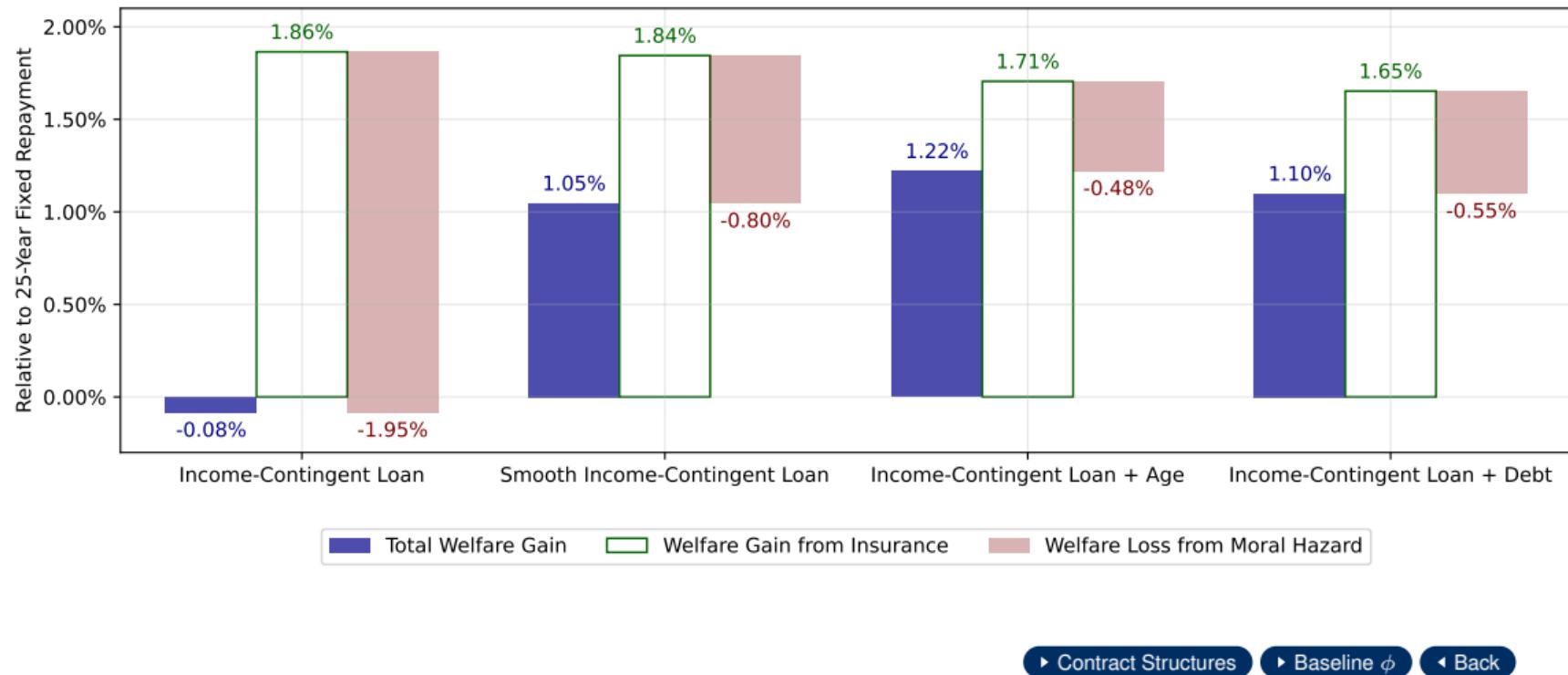
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How INCOME-CONTINGENT LOANS VARY WITH ϕ

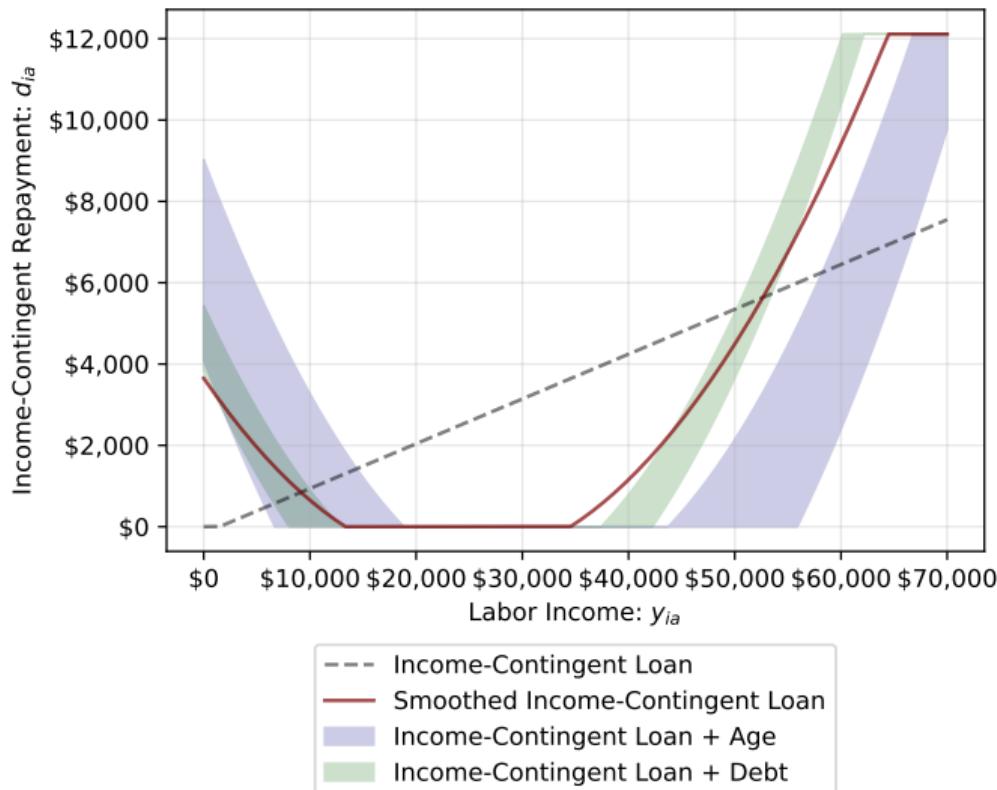


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ALTERNATIVE CONTRACTS REDUCE WELFARE COST OF MORAL HAZARD

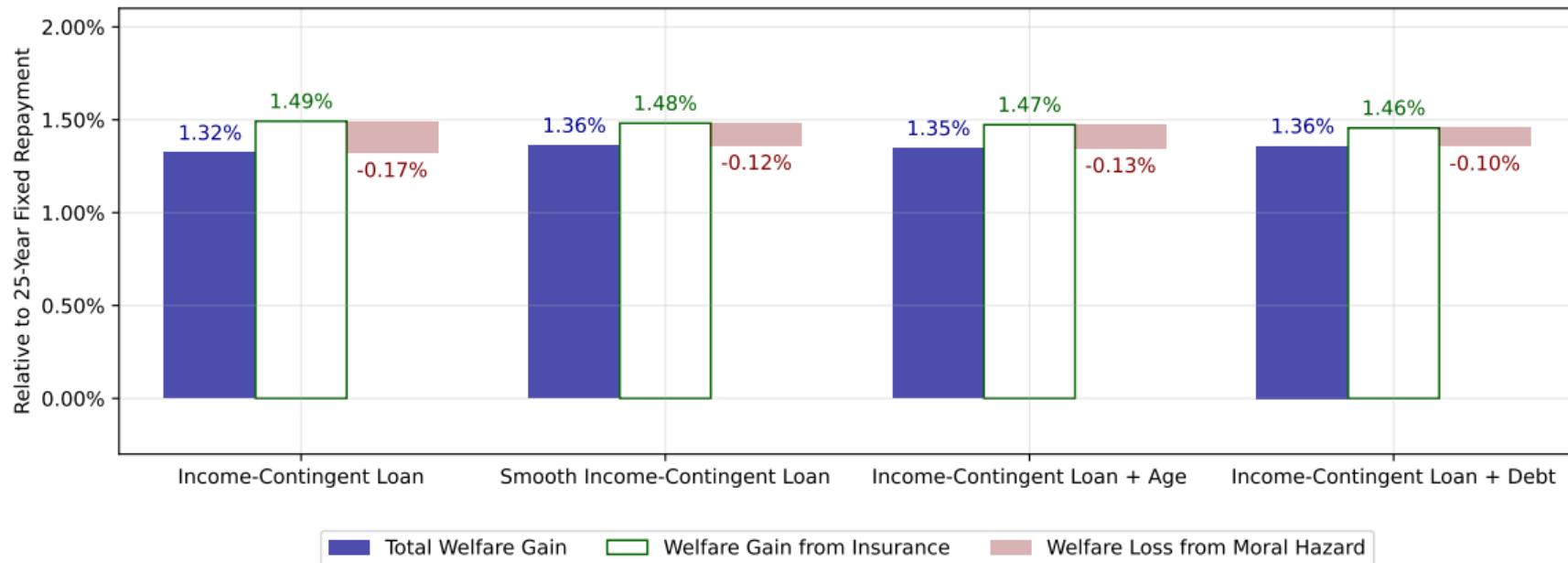


ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: $\phi = 0.37$



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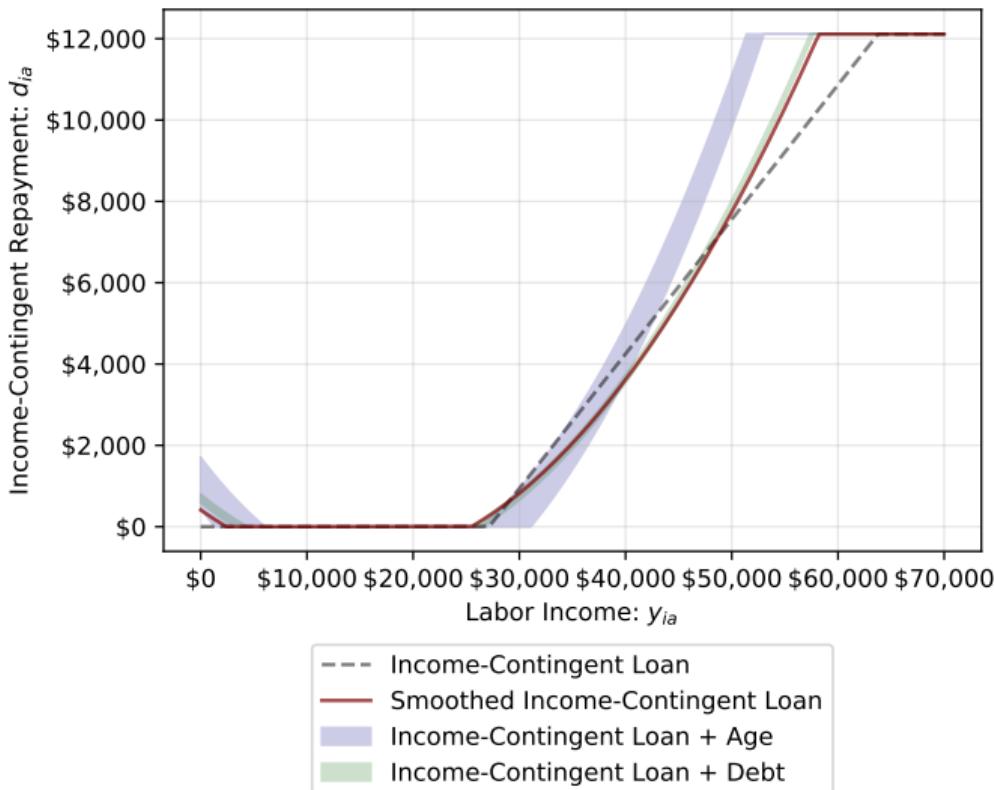
REDUCING WELFARE COST OF MORAL HAZARD: BASELINE ϕ



▶ Contract Structures

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ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: BASELINE ϕ



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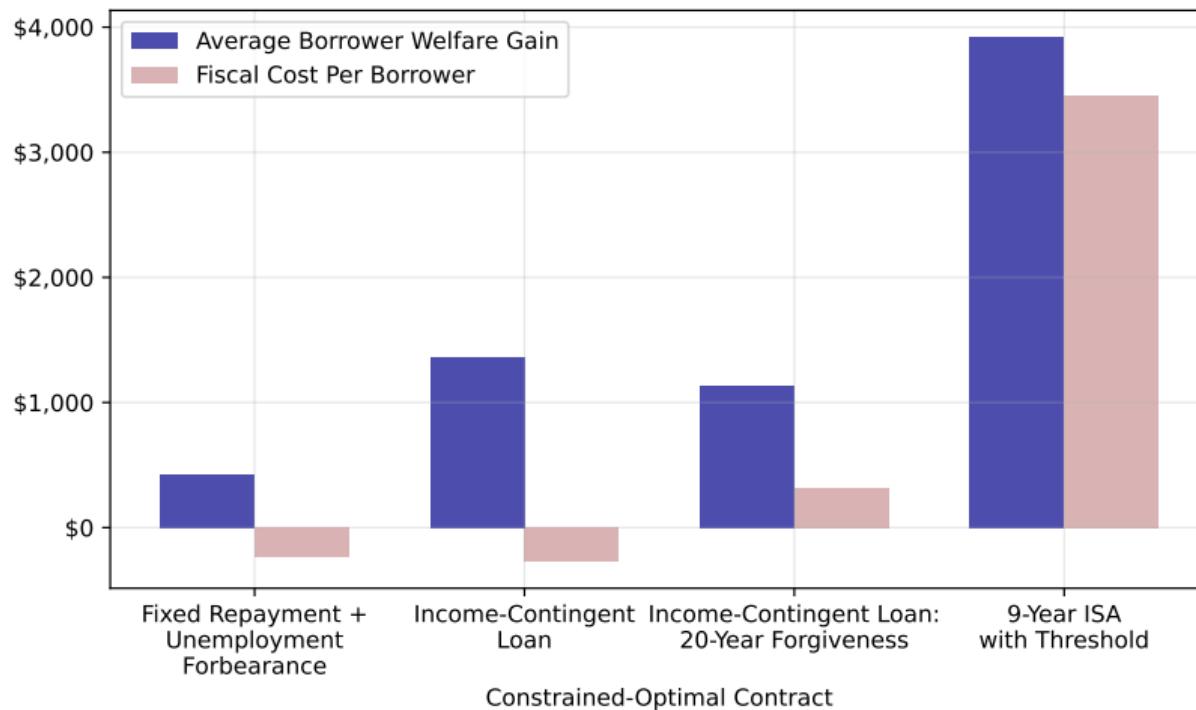
EFFECTS OF ENDOGENOUS CONTRACT SELECTION

| | Constrained-Optimal Contract | |
|---|------------------------------|---------------------------|
| | Income-Contingent Loan | 9-Year ISA with Threshold |
| % Choose 25-Year Fixed Repayment | 29% | 24% |
| Borrower Value of Selection | \$180 | \$1,544 |
| Fiscal Impact of Selection | -\$757 | -\$6,841 |
| Consumption-Equivalent Welfare Gains | | |
| Contract Mandated | 1.32% | 1.99% |
| Selection + Taxes to Balance Budget | 1.29% | 1.64% |
| Welfare Impact of Selection | -0.03% | -0.35% |

- Borrowers choose between two contracts after learning s_0
- After balancing budget, selection **reduces** welfare à la Hirshleifer (1971)

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EFFECTS OF RESTRUCTURING FROM 25-YEAR FIXED REPAYMENT



- To do: effects of endogenous **opt-out** and optimal **restructuring** contract

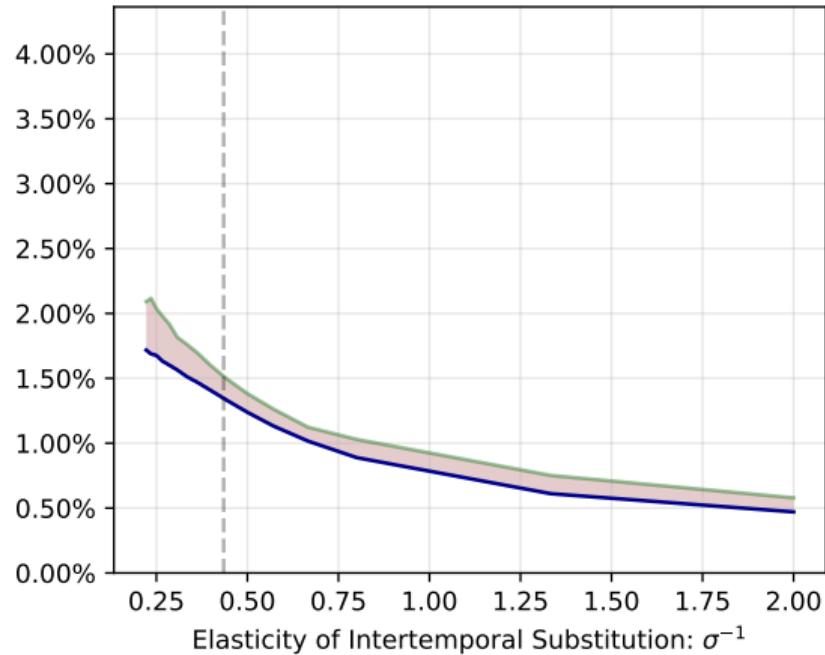
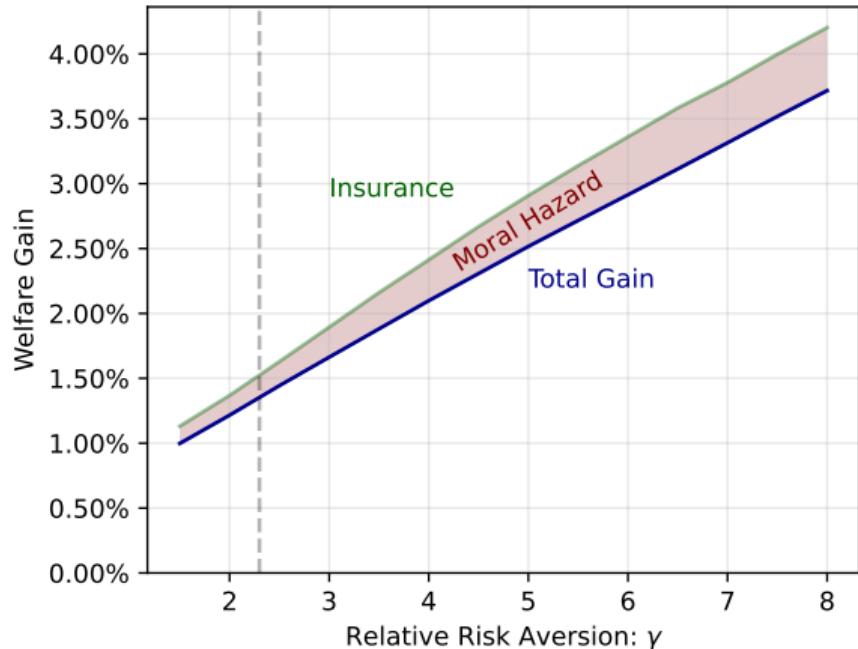
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ADDITIONAL MODEL RESULTS: NORMATIVE

- ① Welfare gains are more sensitive to **risk aversion** than EIS 
- ② Planner's problem is more sensitive to **fixed cost** than Calvo probability 
- ③ No welfare loss from discontinuity in **average** repayment rate 
- ④ **Pure equity** contract does worse than income-contingent loan 
- ⑤ No welfare gain from **combining** forbearance with income-contingent loans 
- ⑥ With **optimal tax** progressivity, forbearance is enough and gains are smaller 
- ⑦ Robustness to **model mispecification**  and **alternative frictions** 

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EFFECTS OF CHANGING RISK AVERSION AND EIS



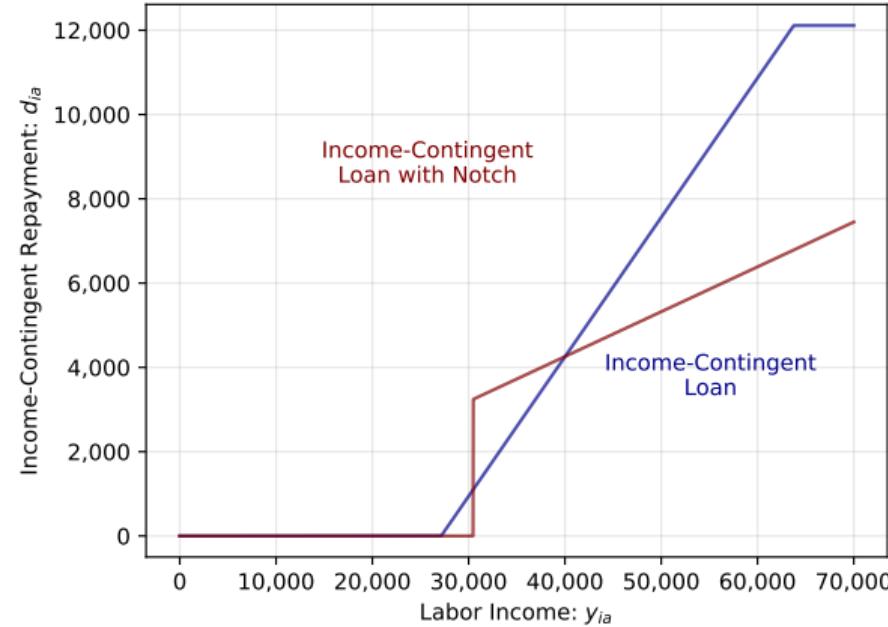
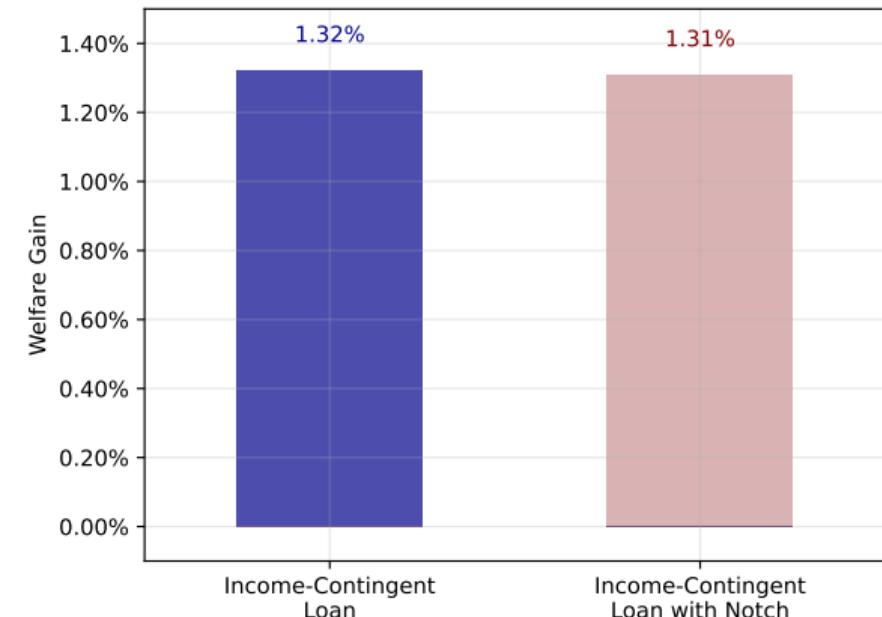
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EFFECTS OF CHANGING FIXED COST AND CALVO PROBABILITY

| Difference from Baseline Model | Welfare Gain = Insurance | + Moral Hazard | ψ^* | K^* |
|--------------------------------|-----------------------------|----------------|---------------|---------------------|
| (1) $f = 0$ | 1.31% | 1.61% | -0.3% | 46% \$29,618 |
| (2) $f = \$2278$ | 1.49% | 1.65% | -0.16% | 64% \$33,915 |
| (3) $\lambda = 1$ | 1.27% | 1.34% | -0.07% | 38% \$28,191 |
| (4) $\lambda = 0.147$ | 1.32% | 1.47% | -0.15% | 40% \$28,492 |
| Baseline Model | 1.32% | 1.47% | -0.15% | 33% \$27,147 |

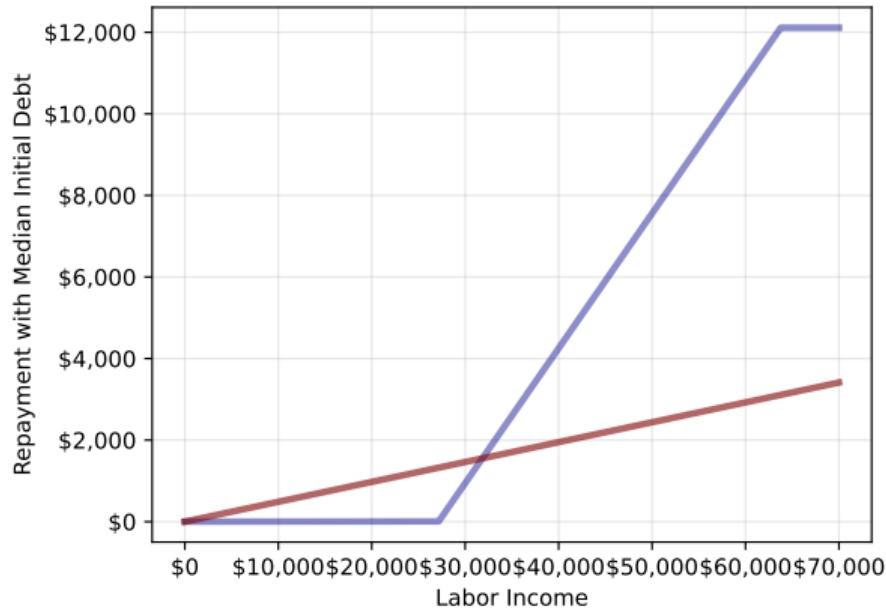
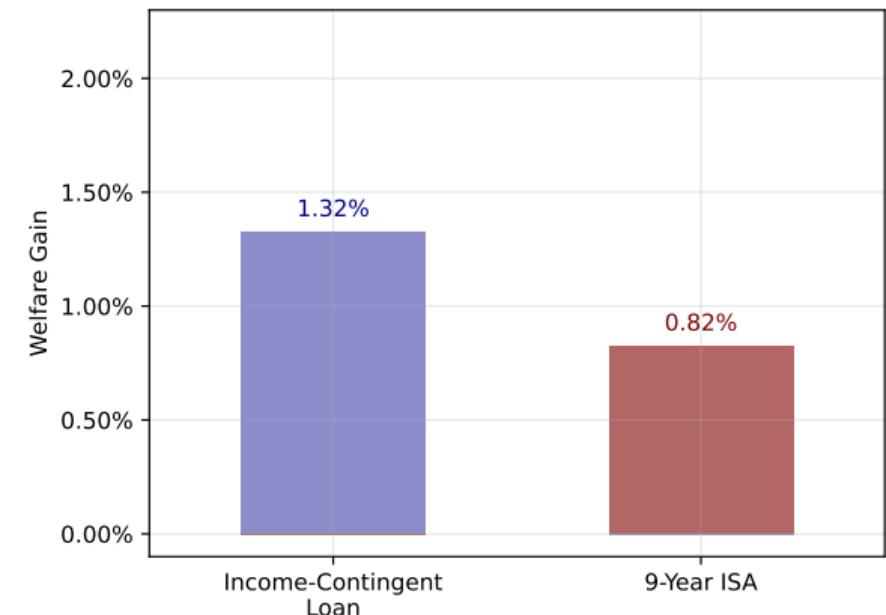
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No LOSS FROM DISCONTINUITY IN AVERAGE REPAYMENT RATE



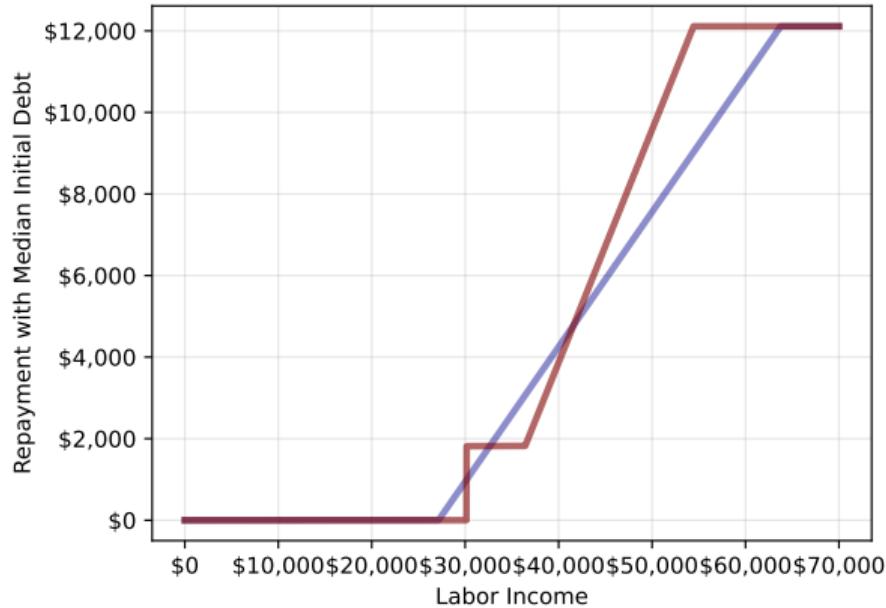
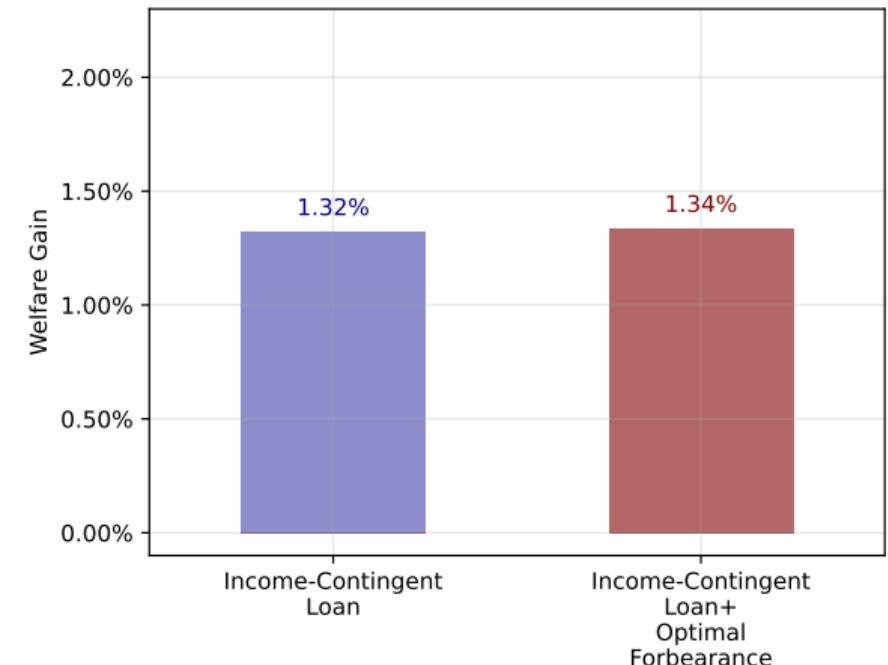
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PURE EQUITY DOES WORSE THAN INCOME-CONTINGENT LOAN



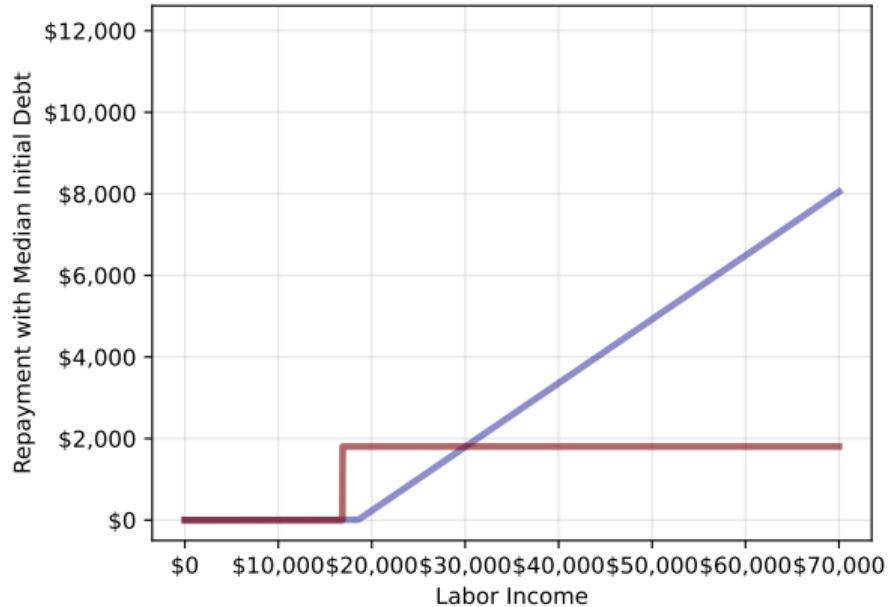
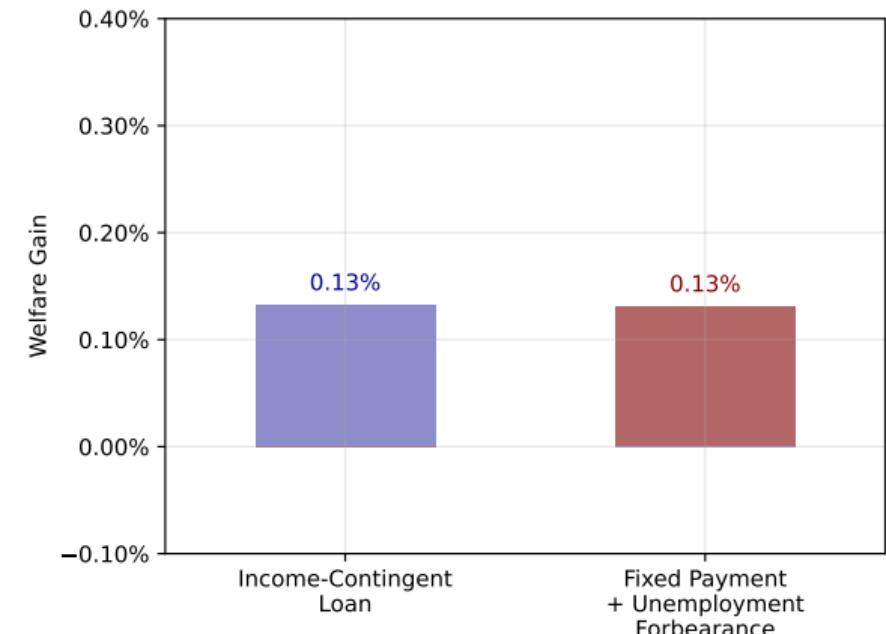
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No GAINS TO ADDING FORBEARANCE TO INCOME-CONTINGENT LOANS



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WELFARE GAINS WITH OPTIMAL TAX PROGRESSIVITY



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ROBUSTNESS TO MODEL MISSPECIFICATION

| | Difference from Baseline Model | Welfare Gain | = Insurance | + Moral Hazard | ψ^* | K^* |
|------|---------------------------------------|--------------|--------------|----------------|------------|-----------------|
| (1) | Occupation Heterogeneity | 1.32% | 1.45% | -0.13% | 41% | \$28,694 |
| (2) | Learning-by-Doing | 1.68% | . | . | 35% | \$36,615 |
| (3) | Fixed Adjustment Cost Only | 1.00% | 1.49% | -0.49% | 21% | \$22,711 |
| (4) | Calvo Adjustment Only | 2.02% | 2.10% | -0.08% | 64% | \$46,452 |
| (5) | Linear Adjustment Cost | 1.74% | 1.87% | -0.13% | 53% | \$43,560 |
| (6) | Wealth Effects on Labor Supply | 0.82% | 1.05% | -0.23% | 37% | \$30,307 |
| (7) | Less Persistent Shocks: $\rho = 0.8$ | 0.90% | 1.14% | -0.23% | 42% | \$34,244 |
| (8) | More Persistent Shocks: $\rho = 0.99$ | 1.35% | 1.63% | -0.28% | 35% | \$18,949 |
| (9) | Non-Normal Permanent Shocks | 1.14% | 1.43% | -0.30% | 28% | \$26,933 |
| (10) | Debt Interest Rate = 2% | 1.96% | 2.14% | -0.18% | 38% | \$47,731 |
| (11) | Planner Discount Rate = R | 1.06% | 1.41% | -0.35% | 29% | \$22,696 |
| (12) | Planner Discount Rate = $R + 4\%$ | 1.60% | 1.65% | -0.05% | 46% | \$34,441 |
| (13) | US Tax System | 1.18% | 1.36% | -0.19% | 38% | \$28,838 |
| (14) | Larger Initial Debt Balances | 3.50% | 4.72% | -1.22% | 36% | \$18,867 |
| (15) | Risk-Free Borrowing: $\tau_b = 0\%$ | 1.23% | 1.44% | -0.21% | 37% | \$27,824 |
| (16) | No Ex-Post Uncertainty | 0.58% | 0.76% | -0.17% | 27% | \$18,098 |
| (17) | No Uncertainty | -0.17% | 0.15% | -0.32% | 21% | \$26,906 |
| | Average | 1.35% | 1.61% | -0.29% | 37% | \$30,277 |
| | Baseline Model | 1.32% | 1.47% | -0.15% | 33% | \$27,147 |

◀ Back: ICL Gain

◀ Back: Additional Results

ROBUSTNESS TO ALTERNATIVE MODELS OF FRICTIONS

| Difference from Baseline Model | Welfare Gain = Insurance | + Moral Hazard | ψ^* | K^* |
|--------------------------------|-----------------------------|----------------|---------------|---------------------|
| (1) $f = 0$ | 1.31% | 1.61% | -0.3% | 46% \$29,618 |
| (2) $f = \$2278$ | 1.49% | 1.65% | -0.16% | 64% \$33,915 |
| (3) $\lambda = 1$ | 1.27% | 1.34% | -0.07% | 38% \$28,191 |
| (4) $\lambda = 0.147$ | 1.32% | 1.47% | -0.15% | 40% \$28,492 |
| (5) Fixed Adjustment Cost Only | 1.00% | 1.49% | -0.49% | 21% \$22,711 |
| (6) Calvo Adjustment Only | 2.02% | 2.10% | -0.08% | 64% \$46,452 |
| (7) Linear Adjustment Cost | 1.74% | 1.87% | -0.13% | 53% \$43,560 |
| Baseline Model | 1.32% | 1.47% | -0.15% | 33% \$27,147 |

- Loss from moral hazard is larger when adjustment is more **state**-dependent
- Larger gains with **linear** adjustment costs: more insurance and less moral hazard

◀ Back: ICL Gain

◀ Back: Additional Results

SHORTCUTS IN ADOBE ACROBAT

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