

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

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This Paper: Insurance vs. Moral Hazard

- + Insurance
 - Disincentivize labor supply
 - + Encourage investment & risk-taking
 - Incentivize over-borrowing
 - Adverse selection

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 \approx **restructuring**

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
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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 Mortgages with more risk-sharing Shiller 2004, Caplin et al. 2007, Mian-Sufi 2014, Piskorski-Seru 2018, 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 (avg. $\approx \$20K$ 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

► ICL Prevalence

► Variable Definitions

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

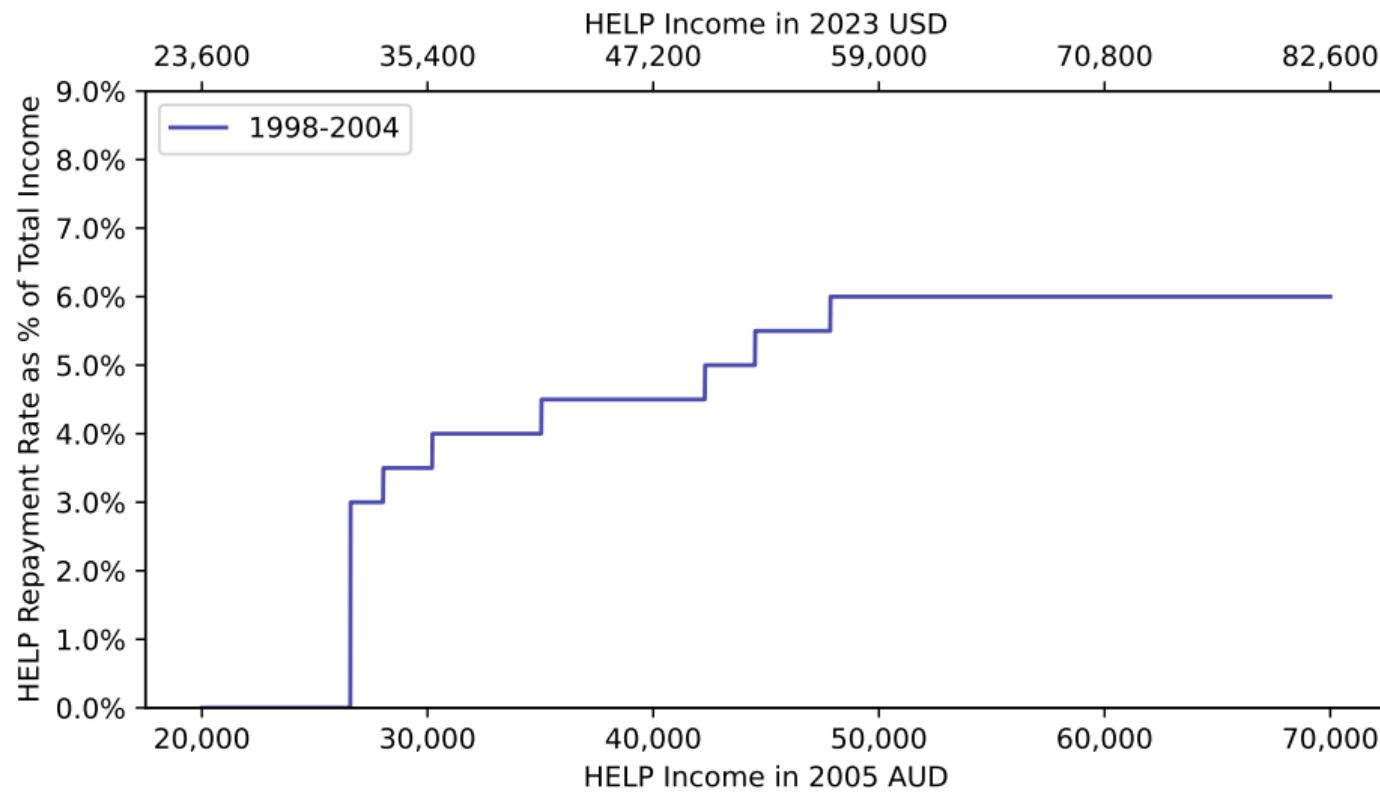
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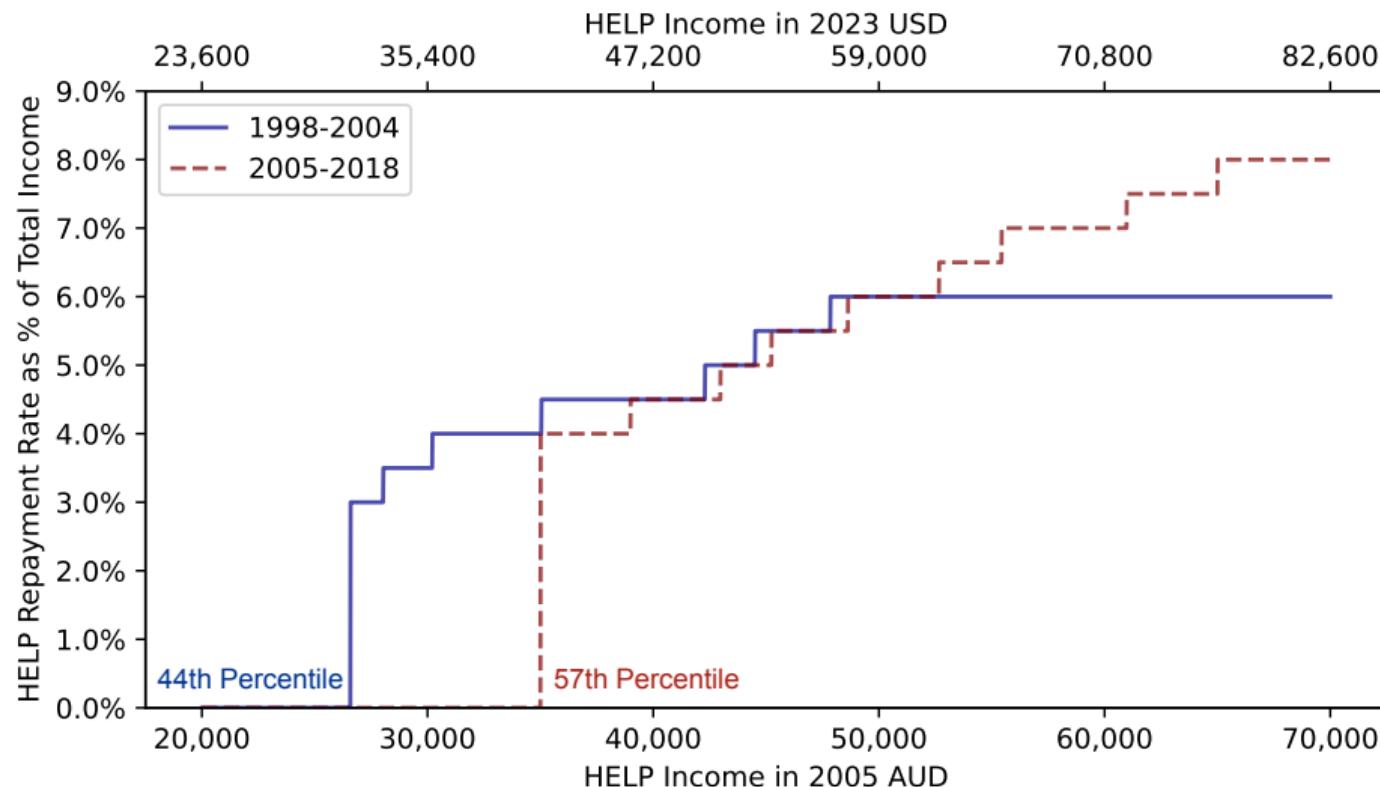
Good setting to identify **labor supply responses** to income-contingent repayment

► Differences from US

IDENTIFYING VARIATION: DISCONTINUITIES IN REPAYMENT RATES

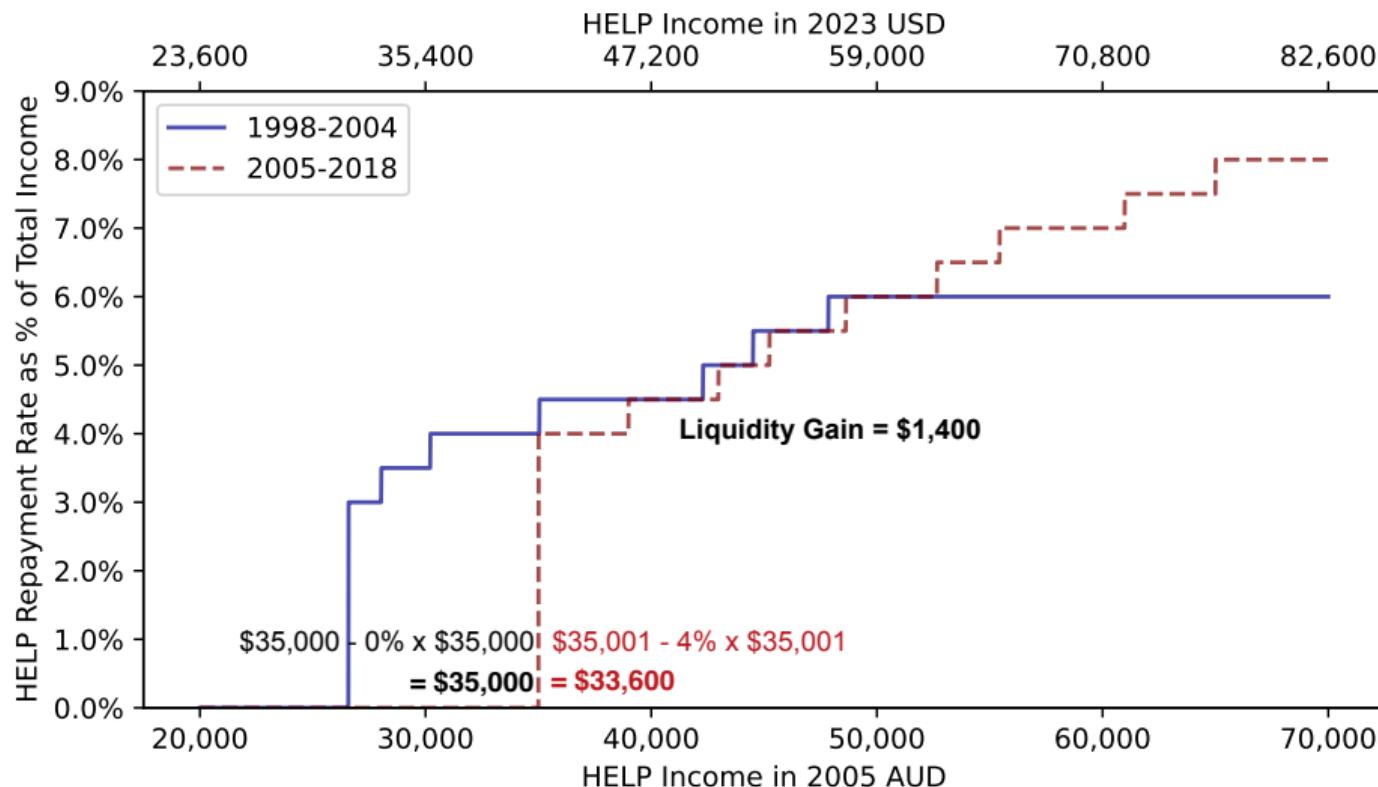


IDENTIFYING VARIATION: POLICY CHANGE TO REPAYMENT RATES



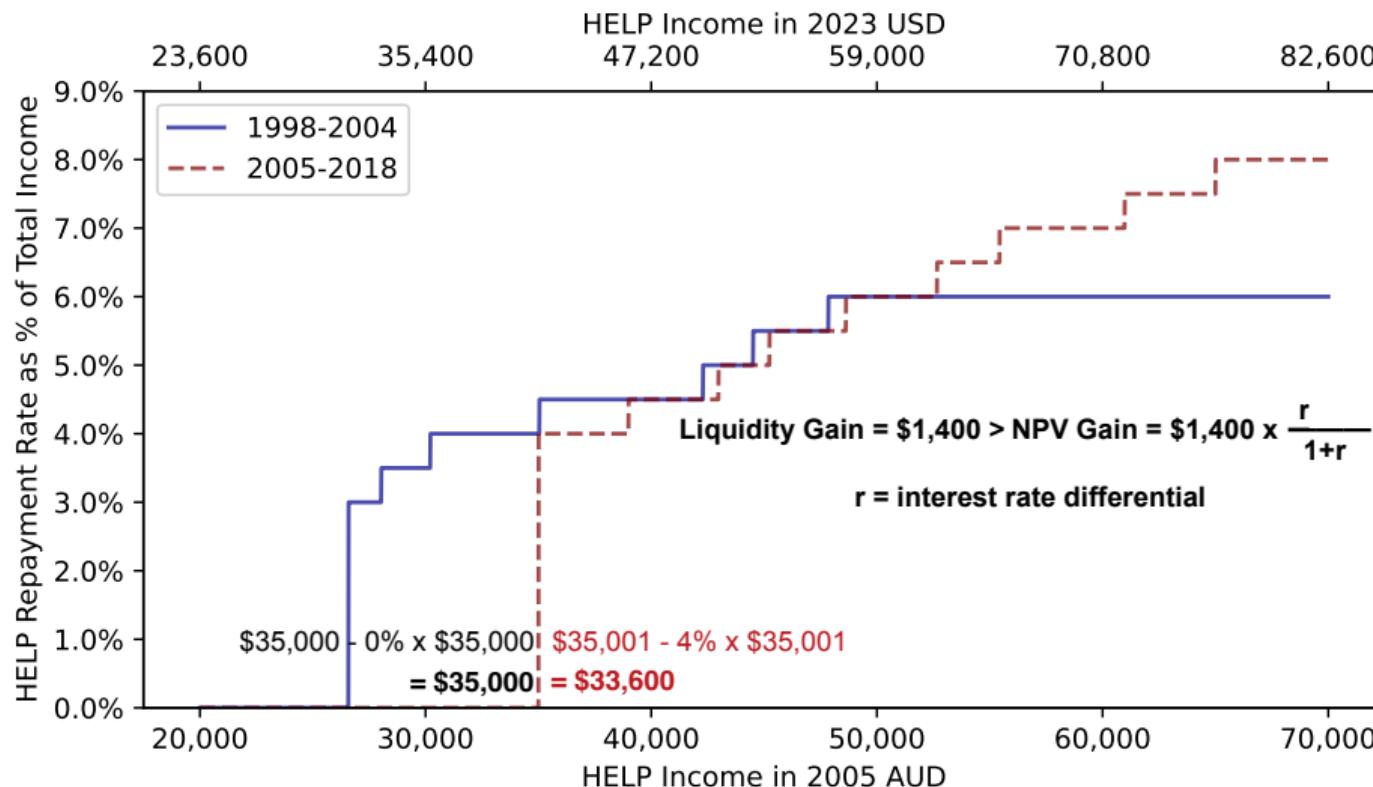
Note: policy change applied to new and existing debtholders

REPAYMENT THRESHOLD INCREASES AVERAGE REPAYMENT RATE



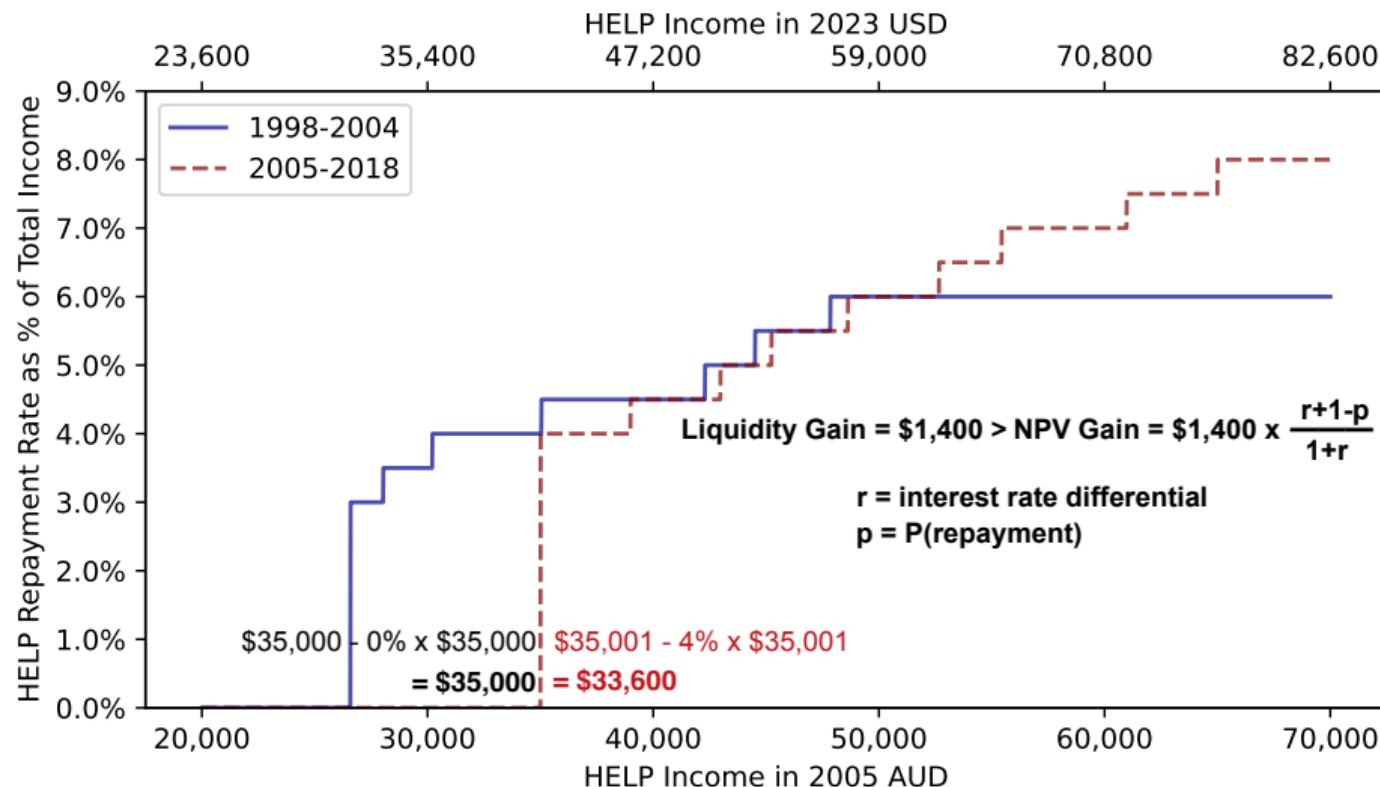
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REPAYMENT THRESHOLD INCREASES LIQUIDITY MORE THAN WEALTH



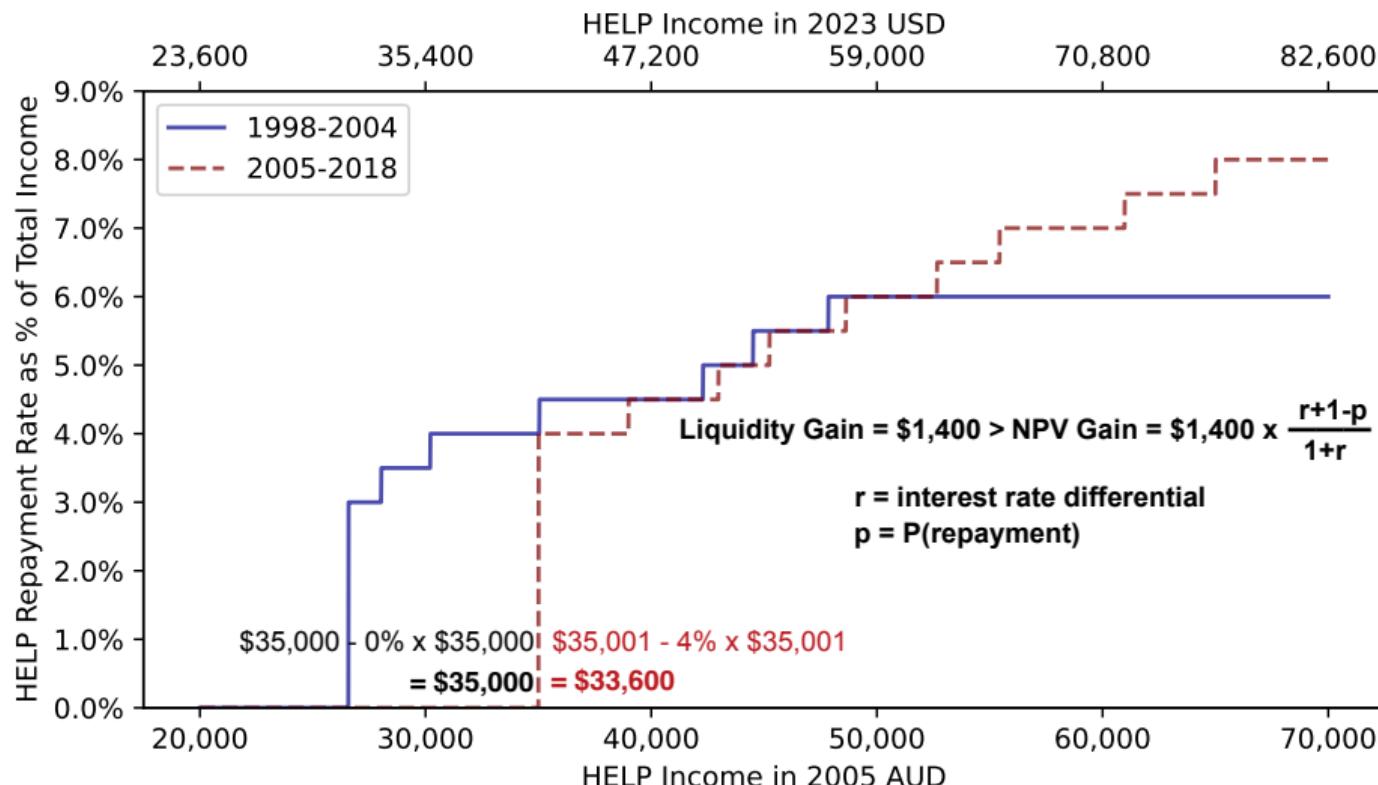
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Note: policy change applied to new and existing debtholders

► 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

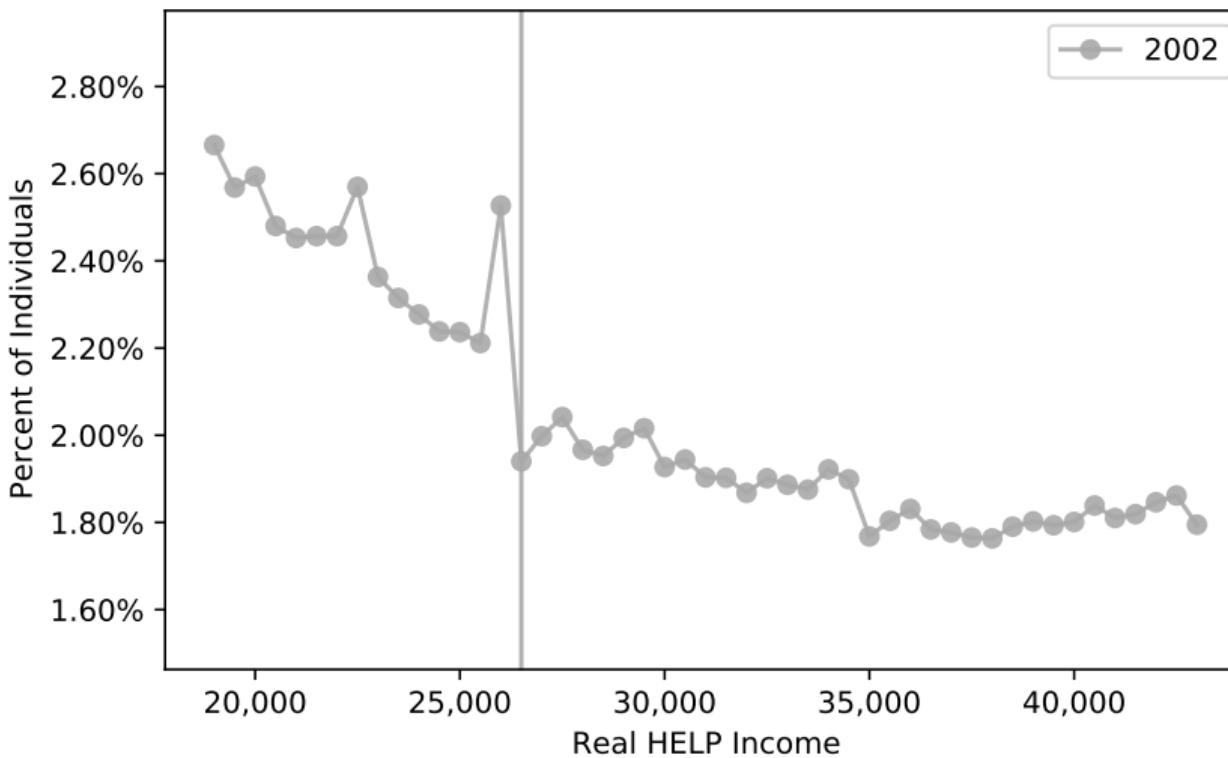
- Mean HELP Income at age 26 = \$34K with 98% from labor income

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

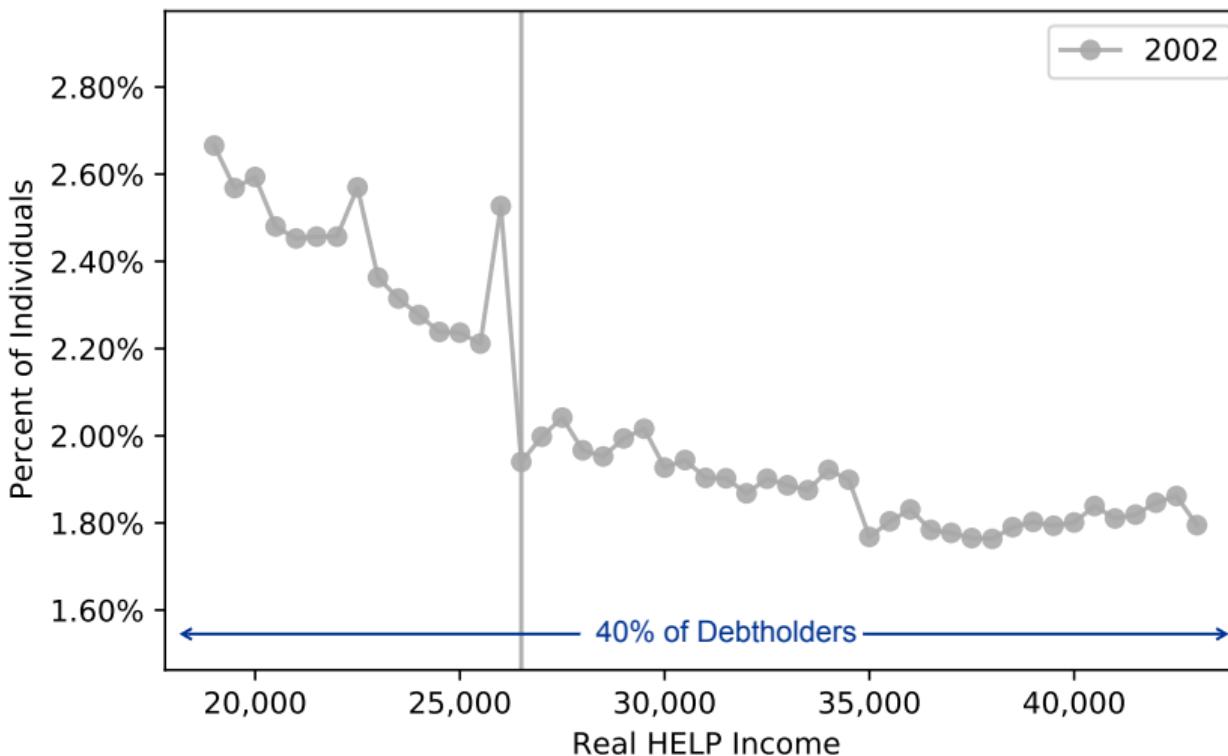
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BORROWERS ADJUST INCOME TO REDUCE REPAYMENTS



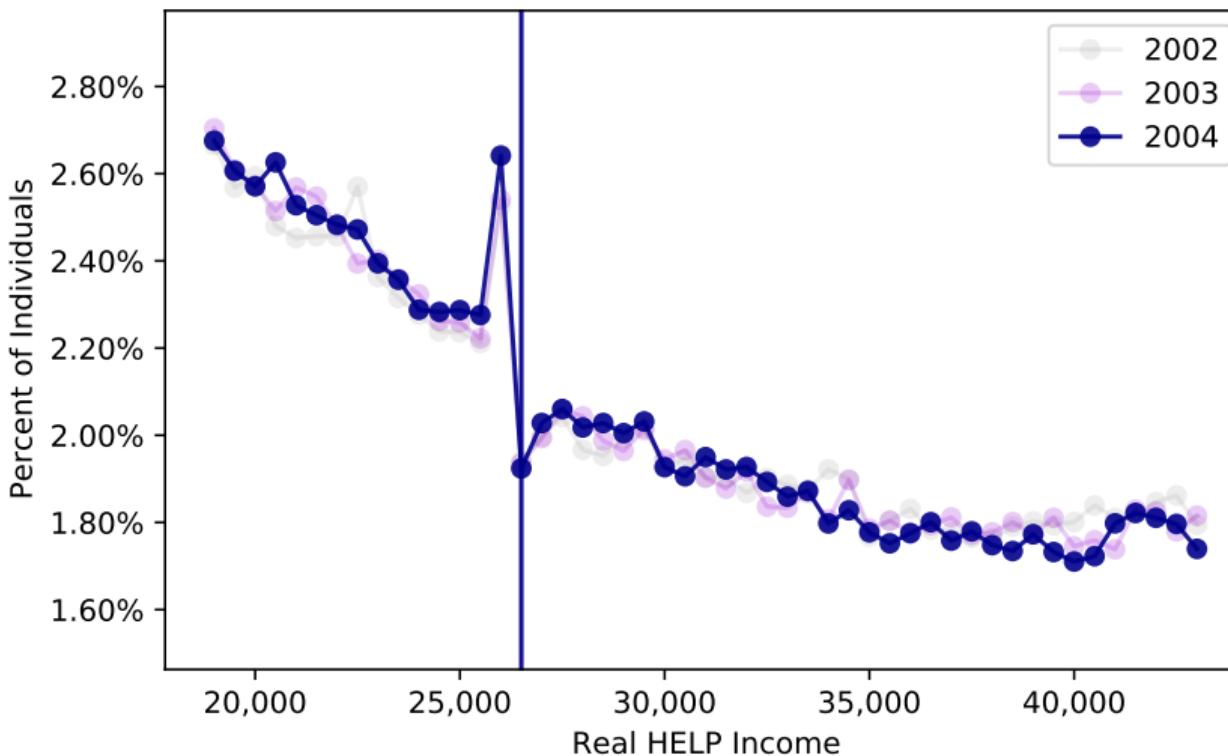
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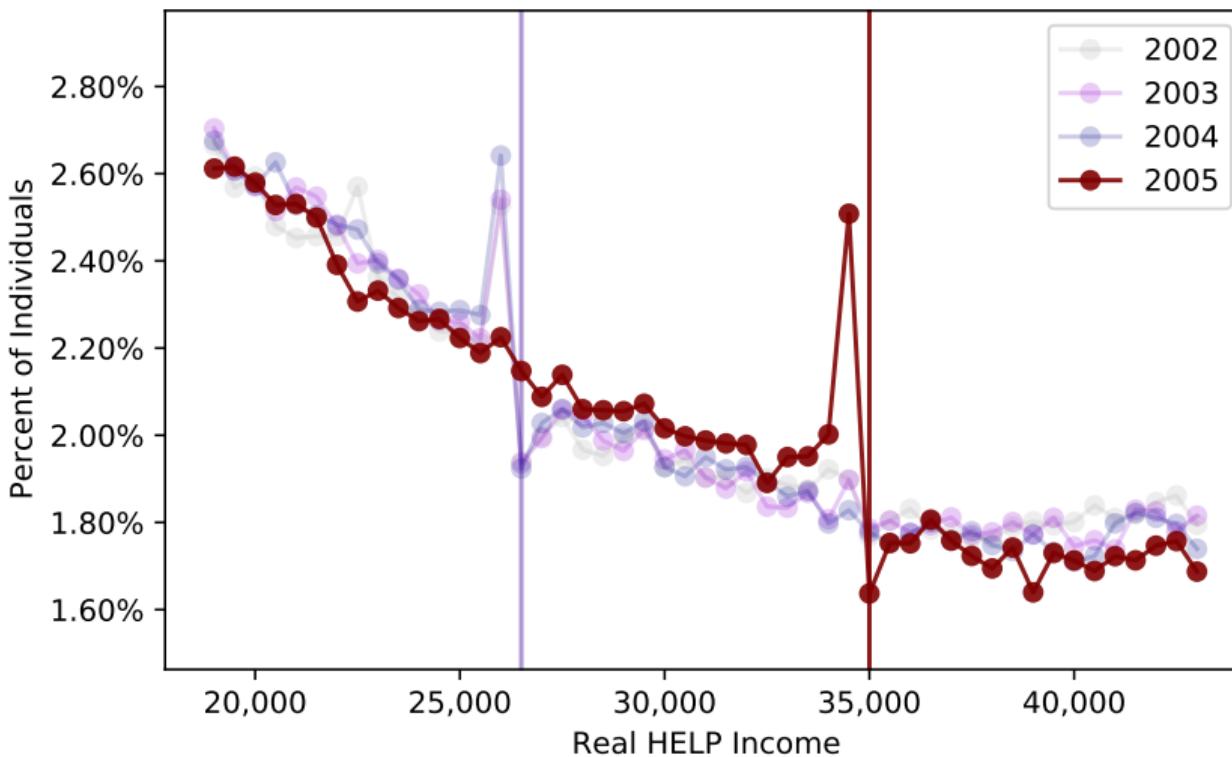
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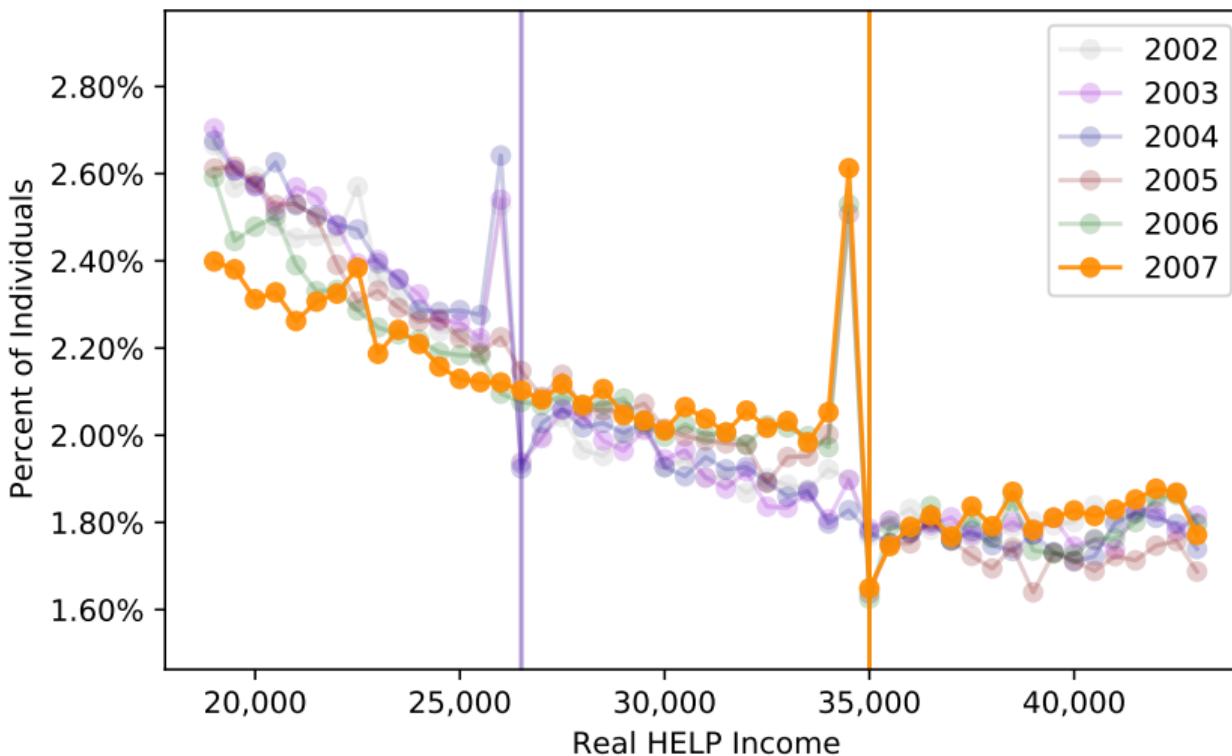
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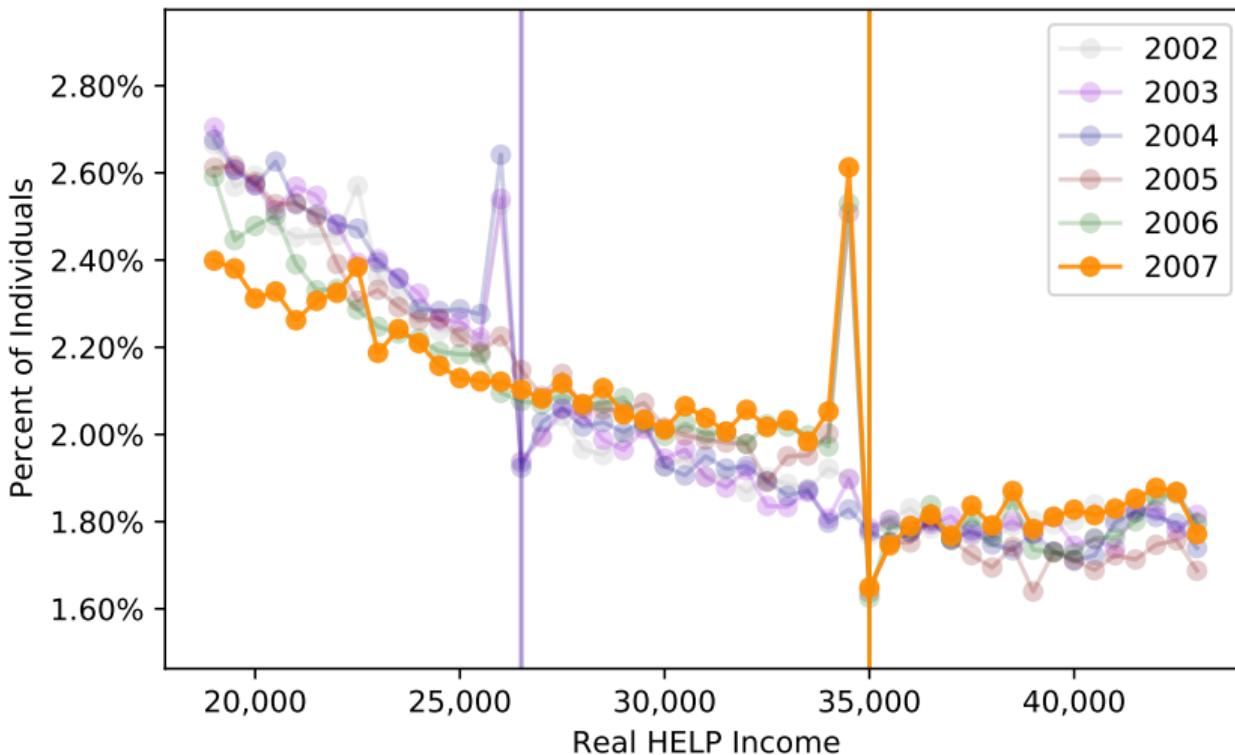
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- Next: does bunching reflect labor supply or evasion?

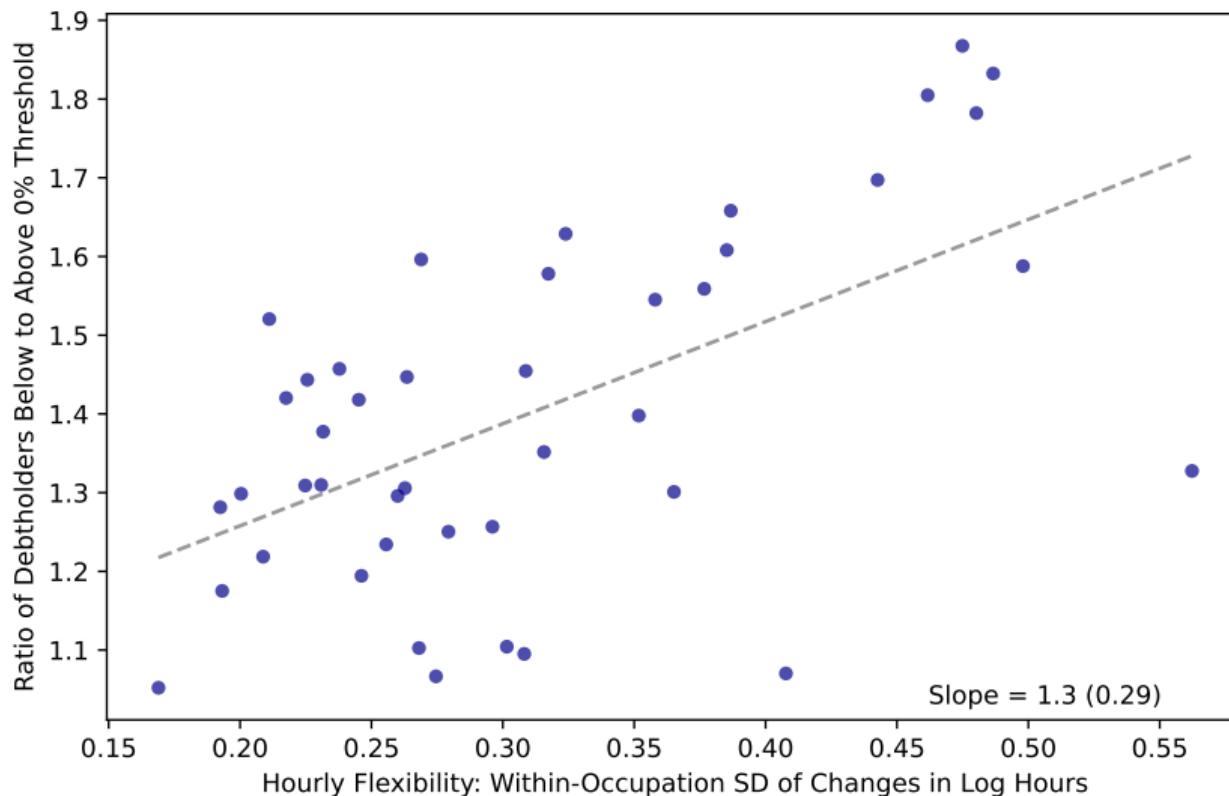
▶ Source

▶ Non-Debt

▶ Labor

▶ vs Tax

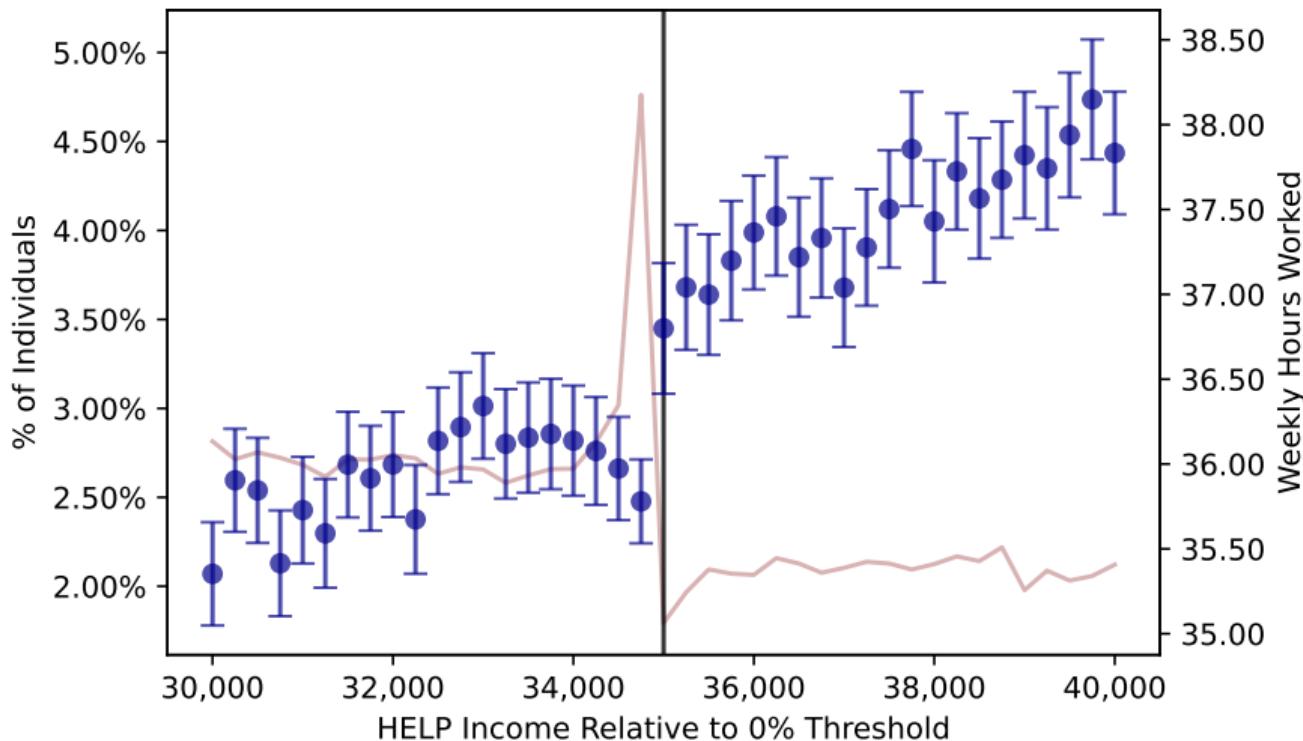
MORE BUNCHING IN OCCUPATIONS WITH GREATER HOURLY FLEXIBILITY



Sample: all wage-earners between 2005-2018

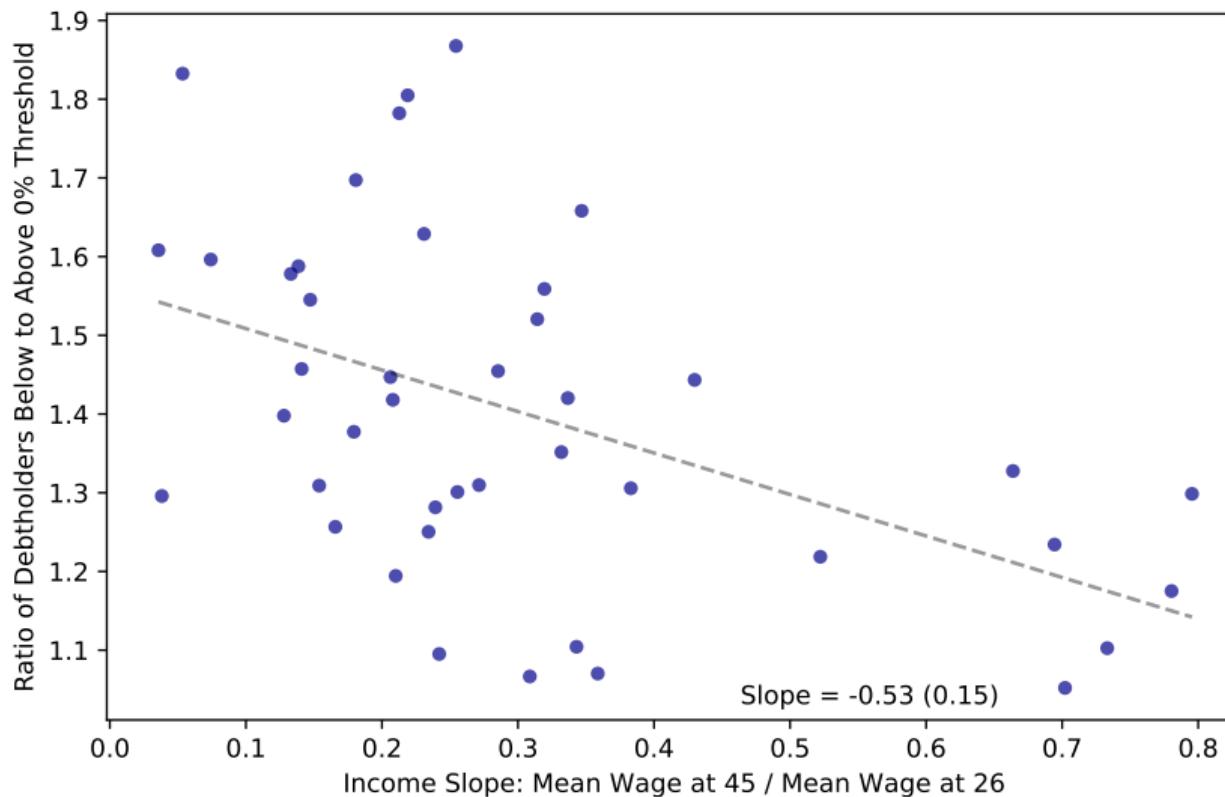
▶ Alt. Measure ▶ Evasion ▶ Table ▶ Profiles ▶ Additional Results

BORROWERS BELOW REPAYMENT THRESHOLD WORK FEWER HOURS



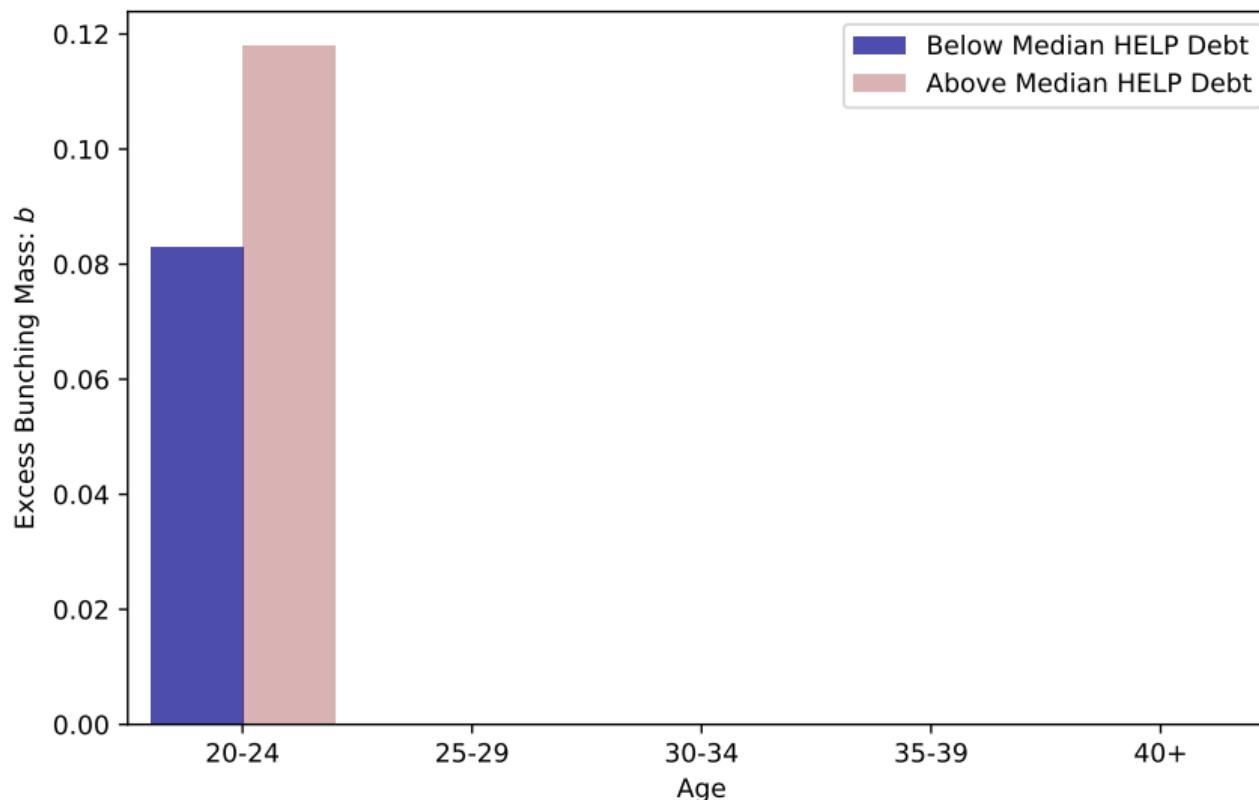
- In 2016, reduction is around **1** hour/week = 1.4 fewer weeks per year

P(REPAYMENT) MATTERS: BUNCHING DECREASES WITH WAGE GROWTH



► Multivariate

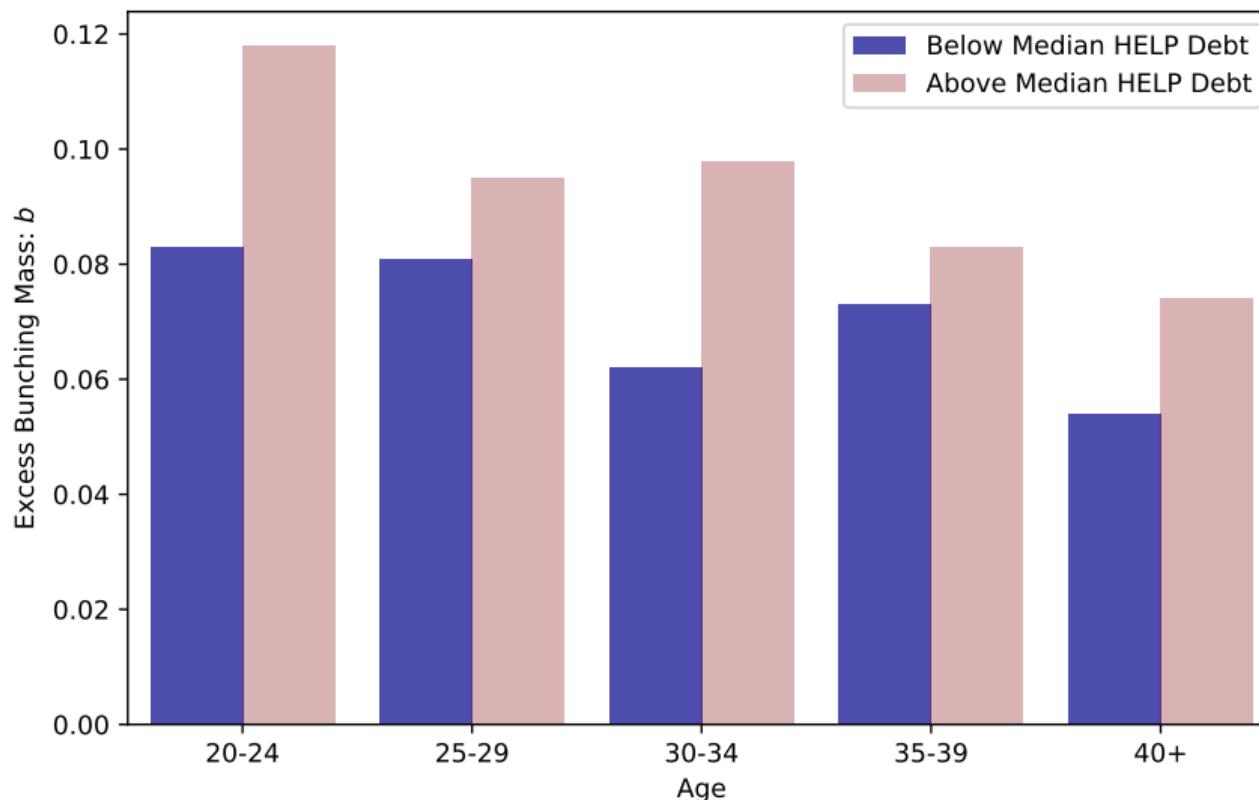
P(REPAYMENT) MATTERS: BUNCHING INCREASES WITH DEBT



Note: confidence intervals omitted due to small size

► *b* Details

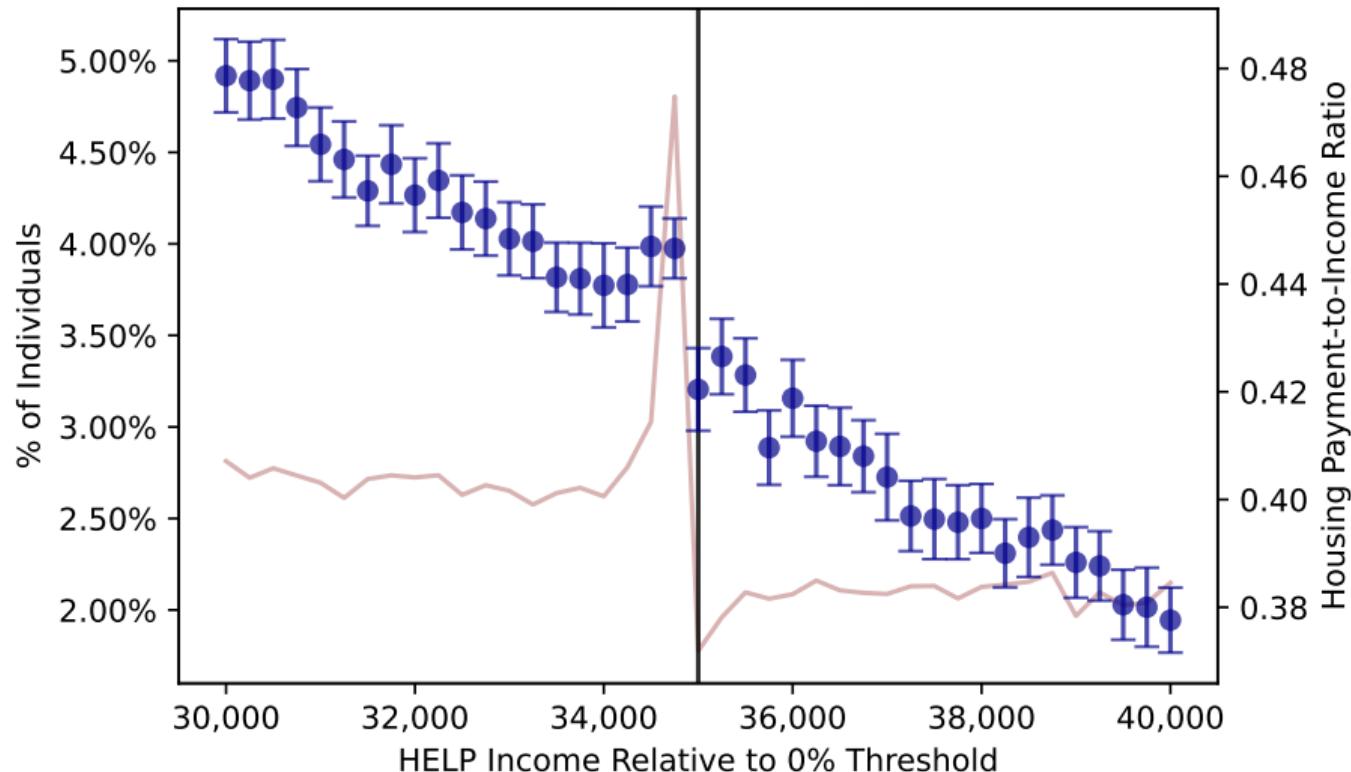
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BUNCHING INCREASES WITH PROXIES FOR LIQUIDITY CONSTRAINTS



► Retirement Savings

► House Prices

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

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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

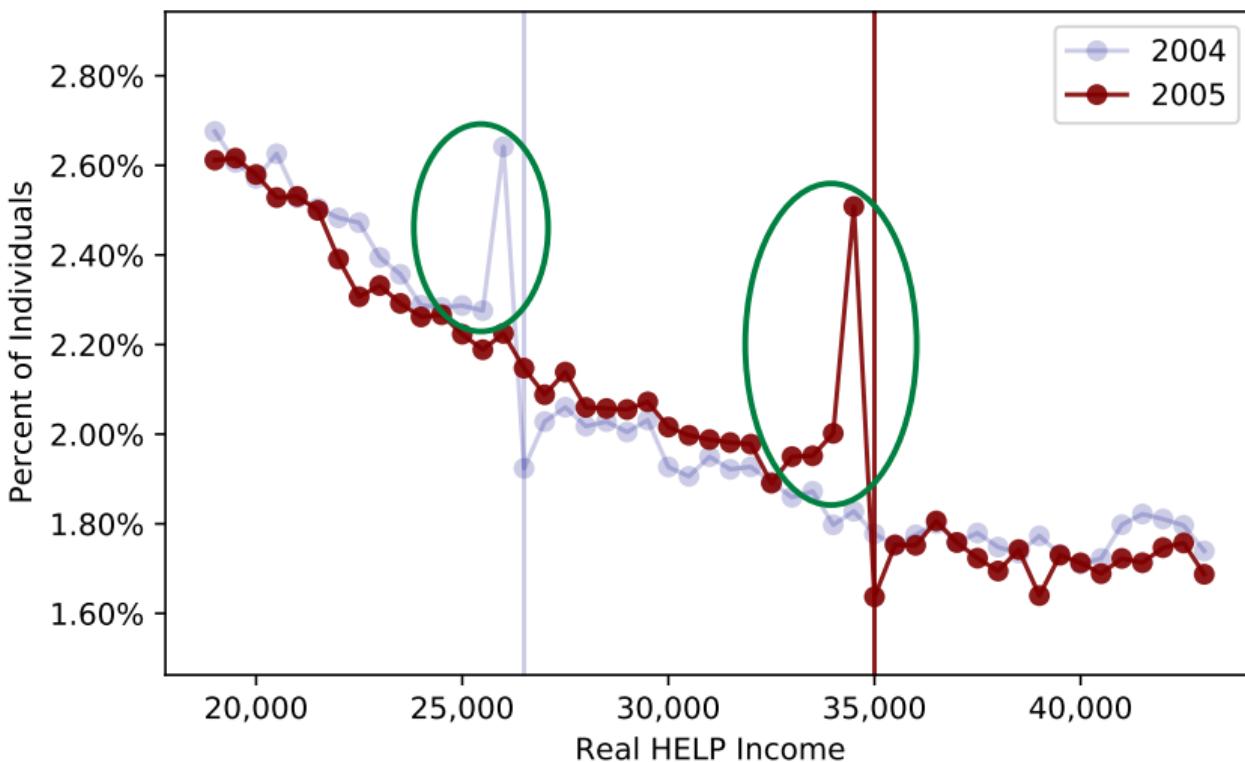
Life cycle model with debt + incomplete markets + endogenous labor supply

- 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

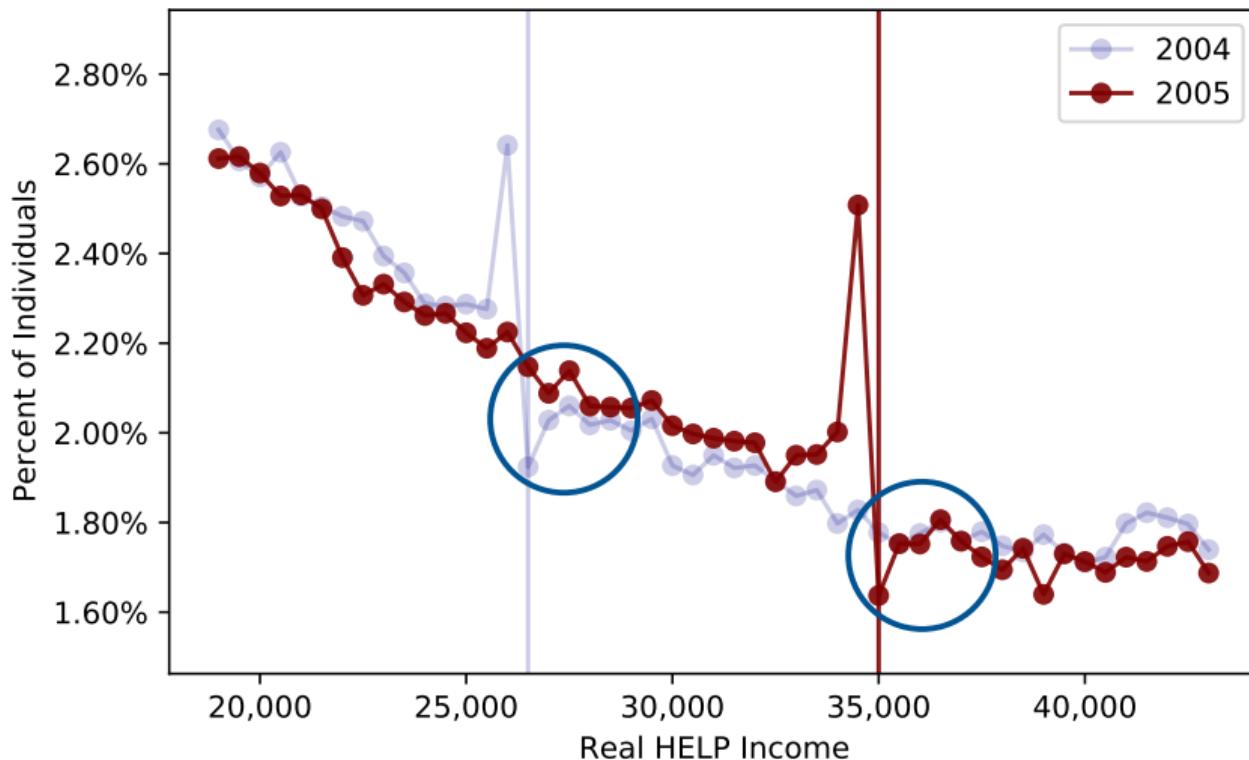
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- After age 64, individuals retire and choose consumption c_a
- **Government**
 - Revenues: progressive income taxes, debt repayments
 - Expenses: means-tested unemployment benefits & retirement pension, initial debt

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

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 - Robustness: linear adjustment costs
 - Extension: add learning-by-doing to generate long-run cost of bunching

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

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

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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$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

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

PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

$$y_a = \ell_a w_a, \quad \log w_a = g_a + \theta_a + \epsilon_a$$

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

- 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

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

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

SECOND-STAGE SIMULATED METHOD OF MOMENTS: IDENTIFICATION

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

- **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

SECOND-STAGE SIMULATED METHOD OF MOMENTS: IDENTIFICATION

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

- 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
- No panel data on **hours** \Rightarrow wage profile & wage risk estimated **jointly**

▶ 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

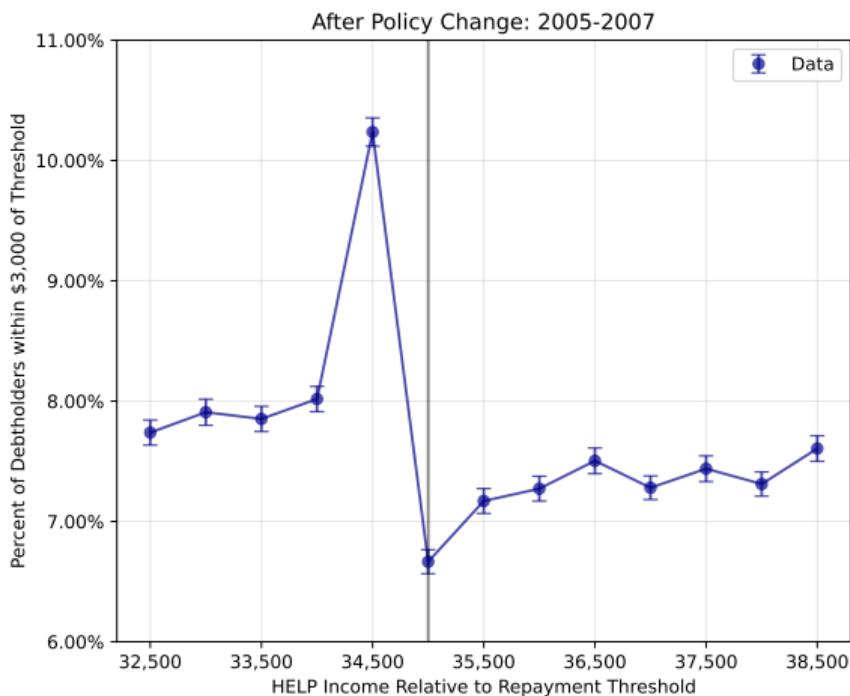
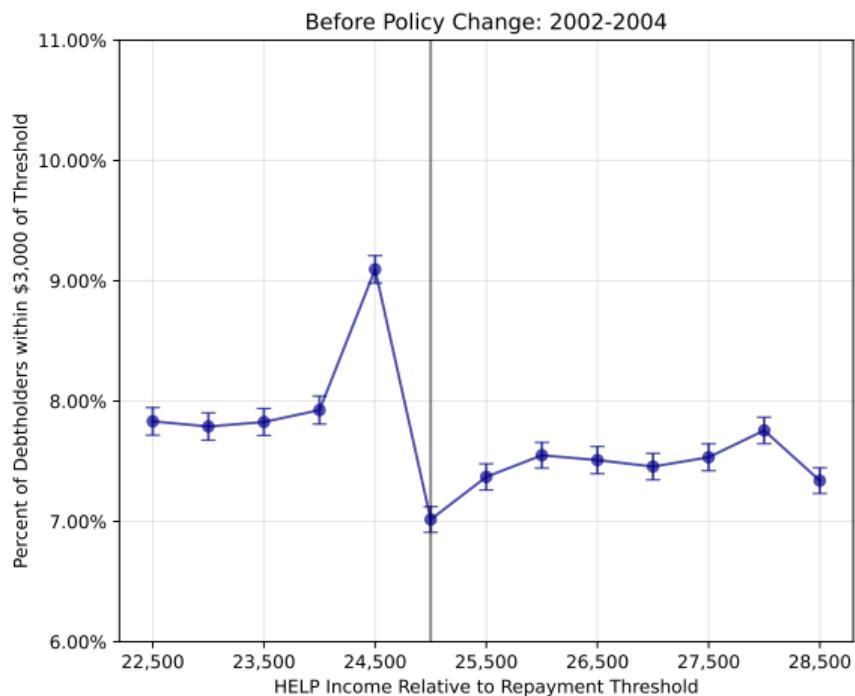
ESTIMATION RESULTS

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

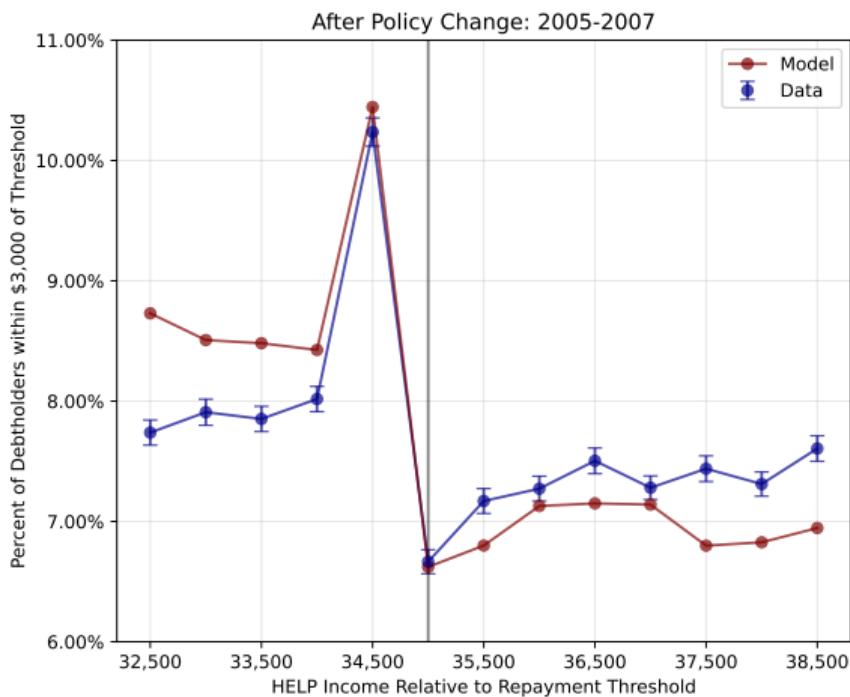
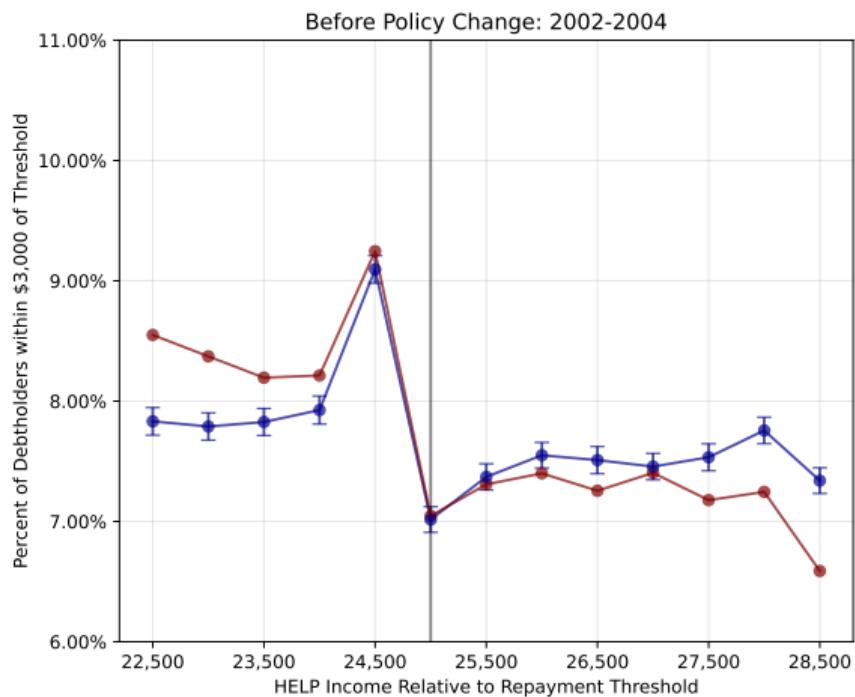
► Comparison with Literature

► All Results with SE

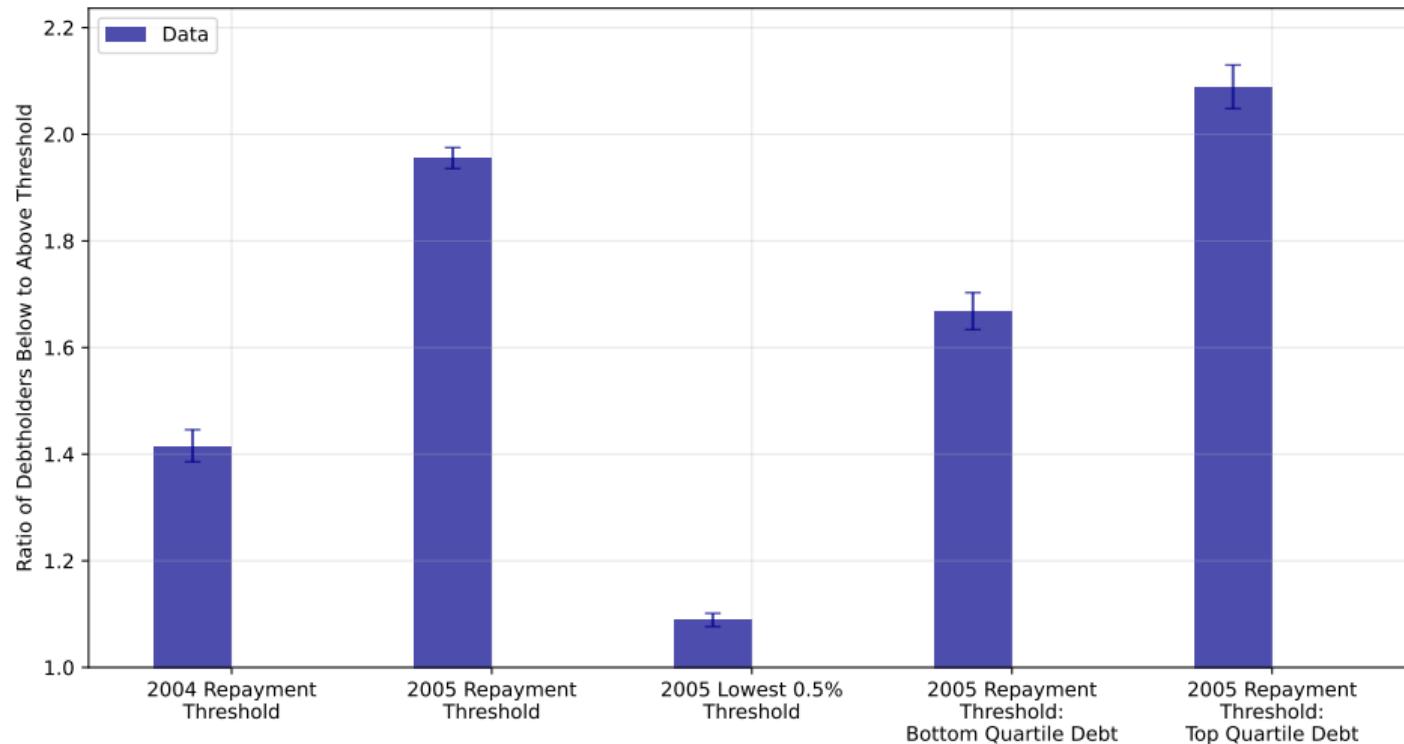
MODEL FIT: BUNCHING BEFORE AND AFTER POLICY CHANGE



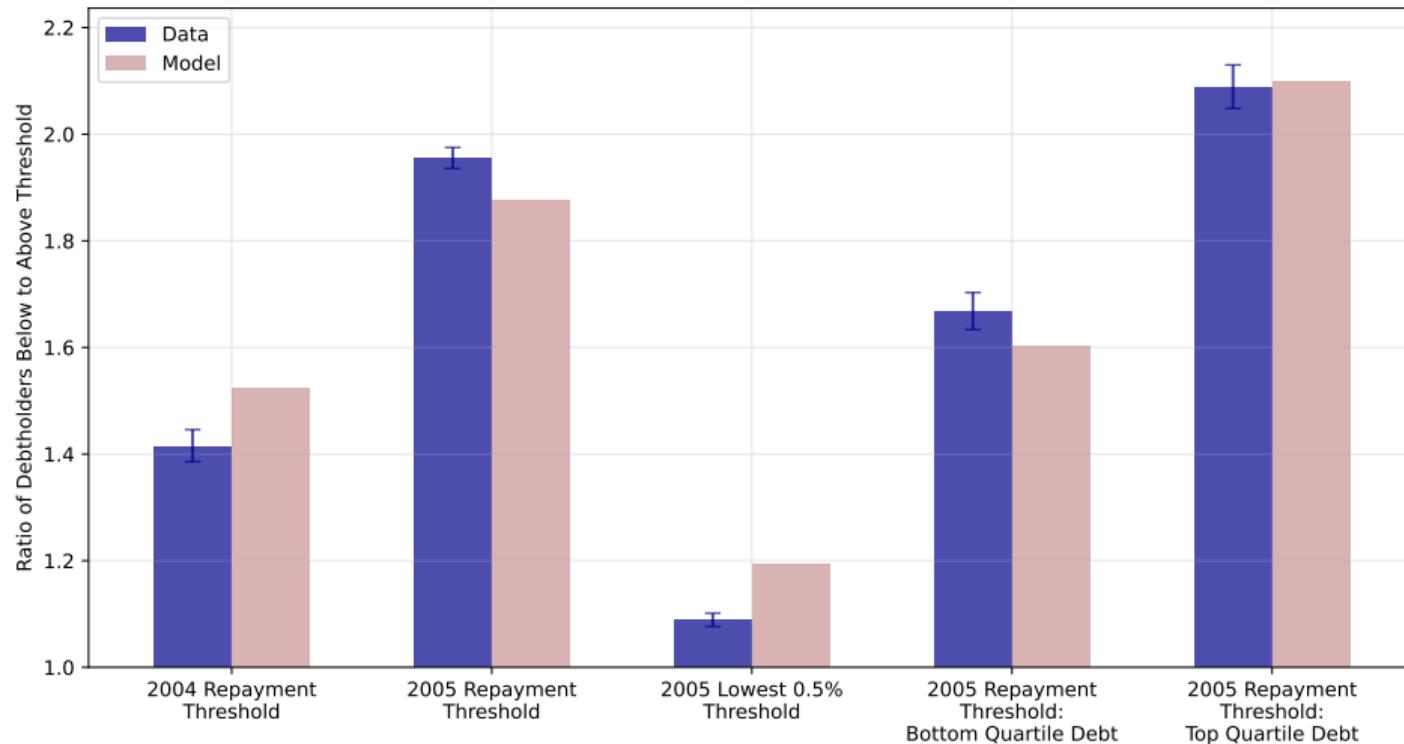
MODEL FIT: BUNCHING BEFORE AND AFTER POLICY CHANGE



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

Conditional on government subsidy for higher education, what repayment contract best balances **insurance** with **moral hazard**?

- **Perspective:** 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, prices held fixed
 - **Caveat:** borrowing and education choices held fixed \approx debt **restructuring**

Conditional on government subsidy for higher education, what repayment contract best balances **insurance** with **moral hazard**?

- **Approach:** solve constrained-planner's problem:

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

(2)

NORMATIVE ANALYSIS

Conditional on government subsidy for higher education, what repayment contract best balances **insurance** with **moral hazard**?

- **Approach:** solve constrained-planner's problem:

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

subject to: (à la Ramsey, not Mirrlees)

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

(2)

Conditional on government subsidy for higher education, what repayment contract best balances **insurance** with **moral hazard**?

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subject to:

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

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$$\mathcal{G} \equiv \mathbf{E}_0 \sum_{a=a_0}^{a_T} \frac{\text{Repayments}_a + \text{Taxes}_a - \text{Transfers}_a}{R_a} \quad (2)$$

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Conditional on government subsidy for higher education, what repayment contract best balances **insurance** with **moral hazard**?

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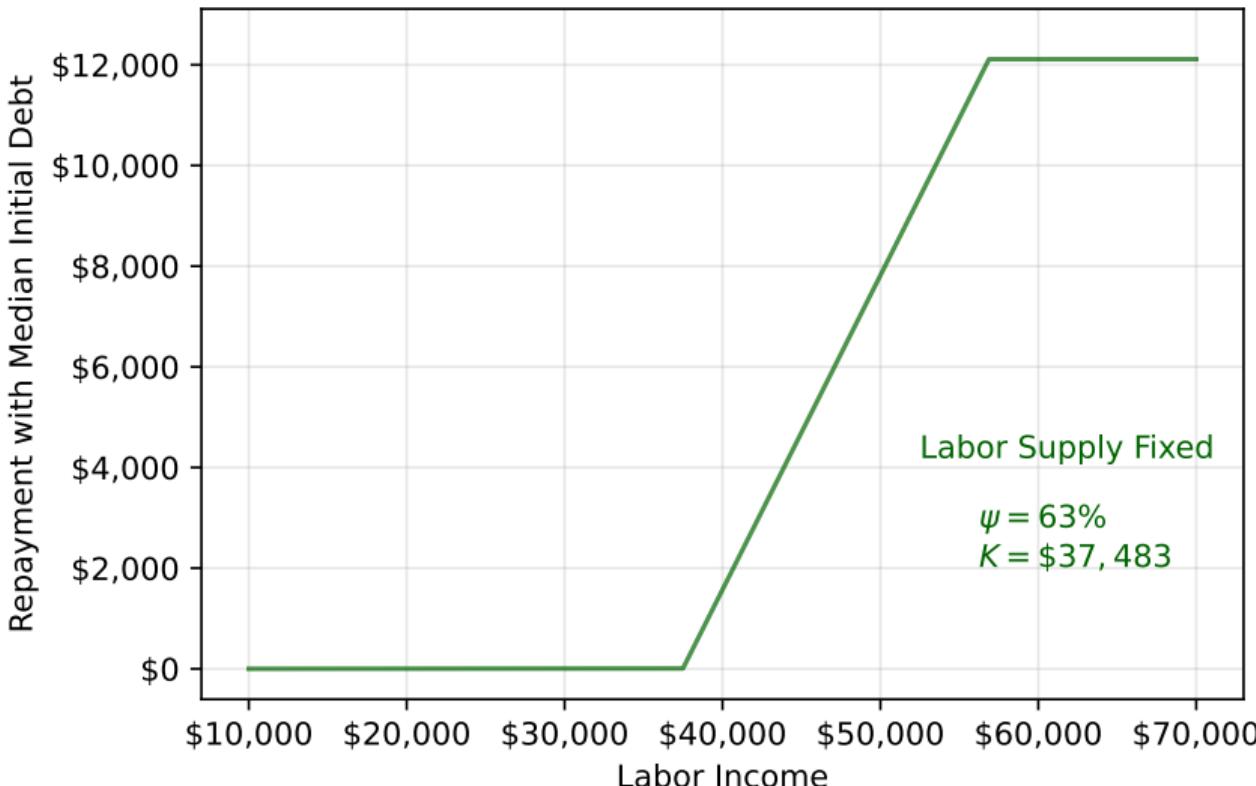
$$\max_{\psi, K} \mathbf{E}_0 \left(V_{a_0}^{1-\gamma} \right)^{\frac{1}{1-\gamma}}$$

subject to:

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

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

SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM

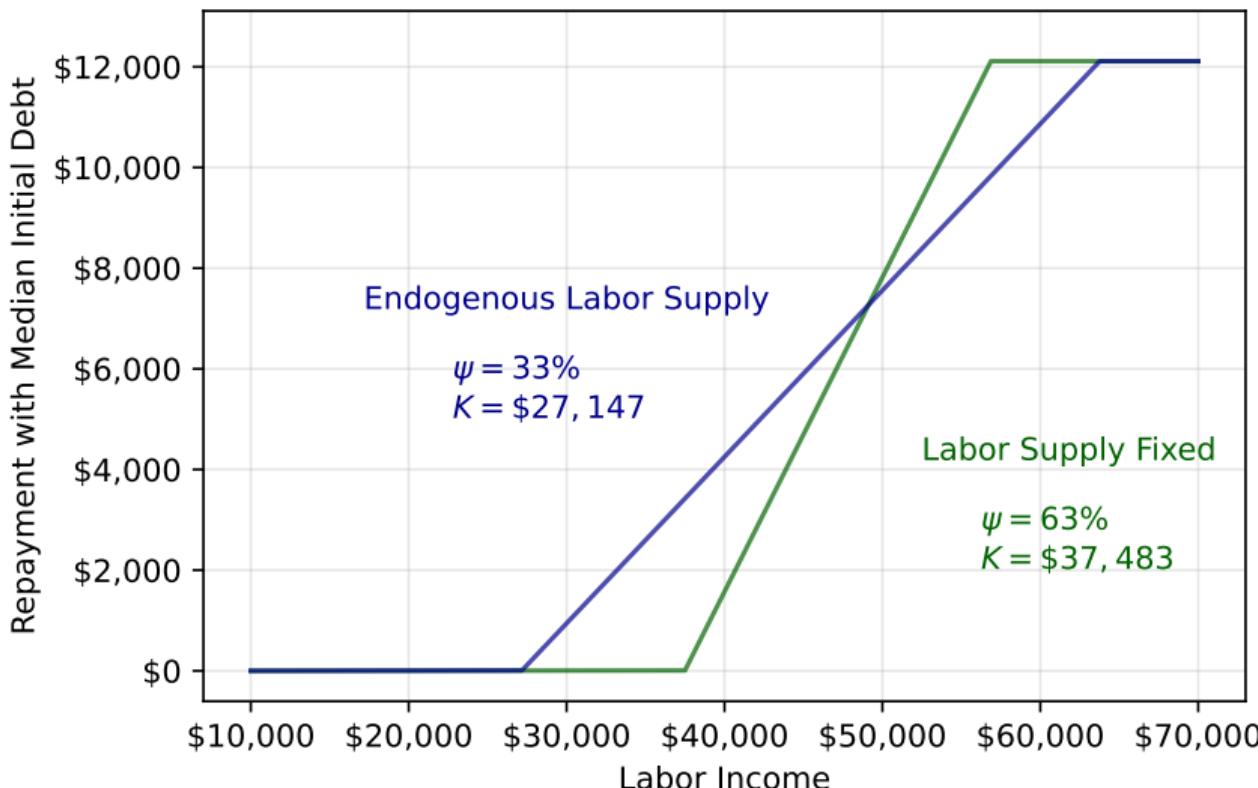


► Smooth Contract

► Compare with Existing

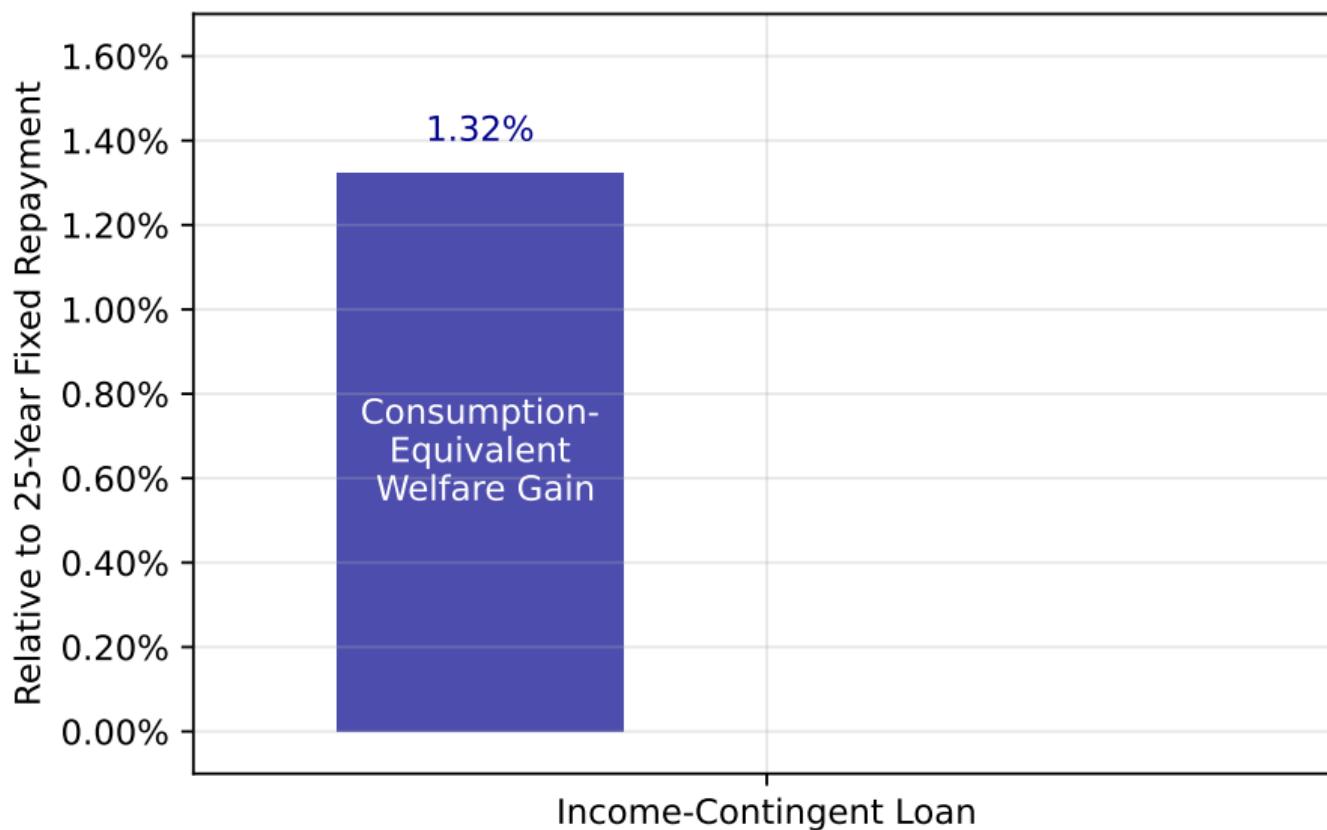
► Non-Budget-Neutral

SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM

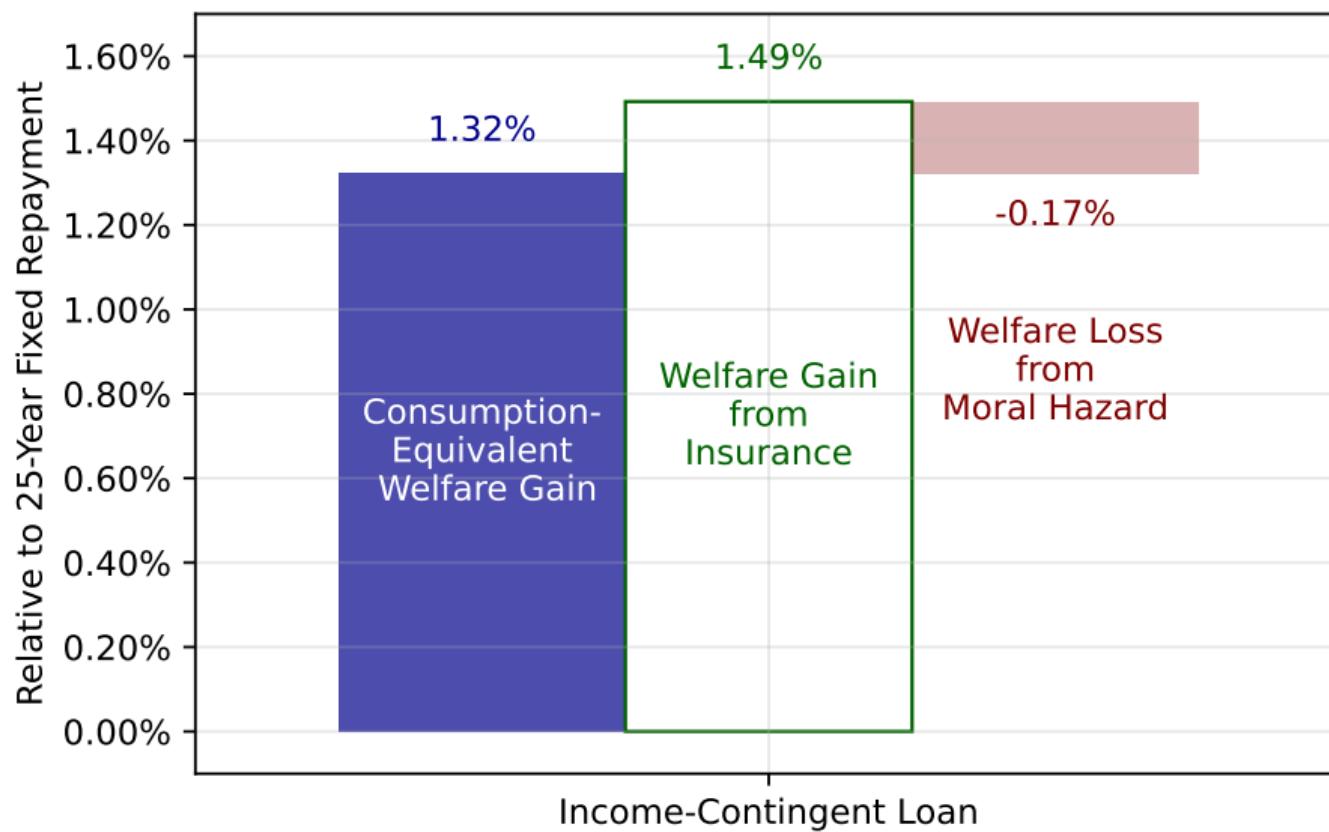


► Smooth Contract ► Compare with Existing ► Non-Budget-Neutral

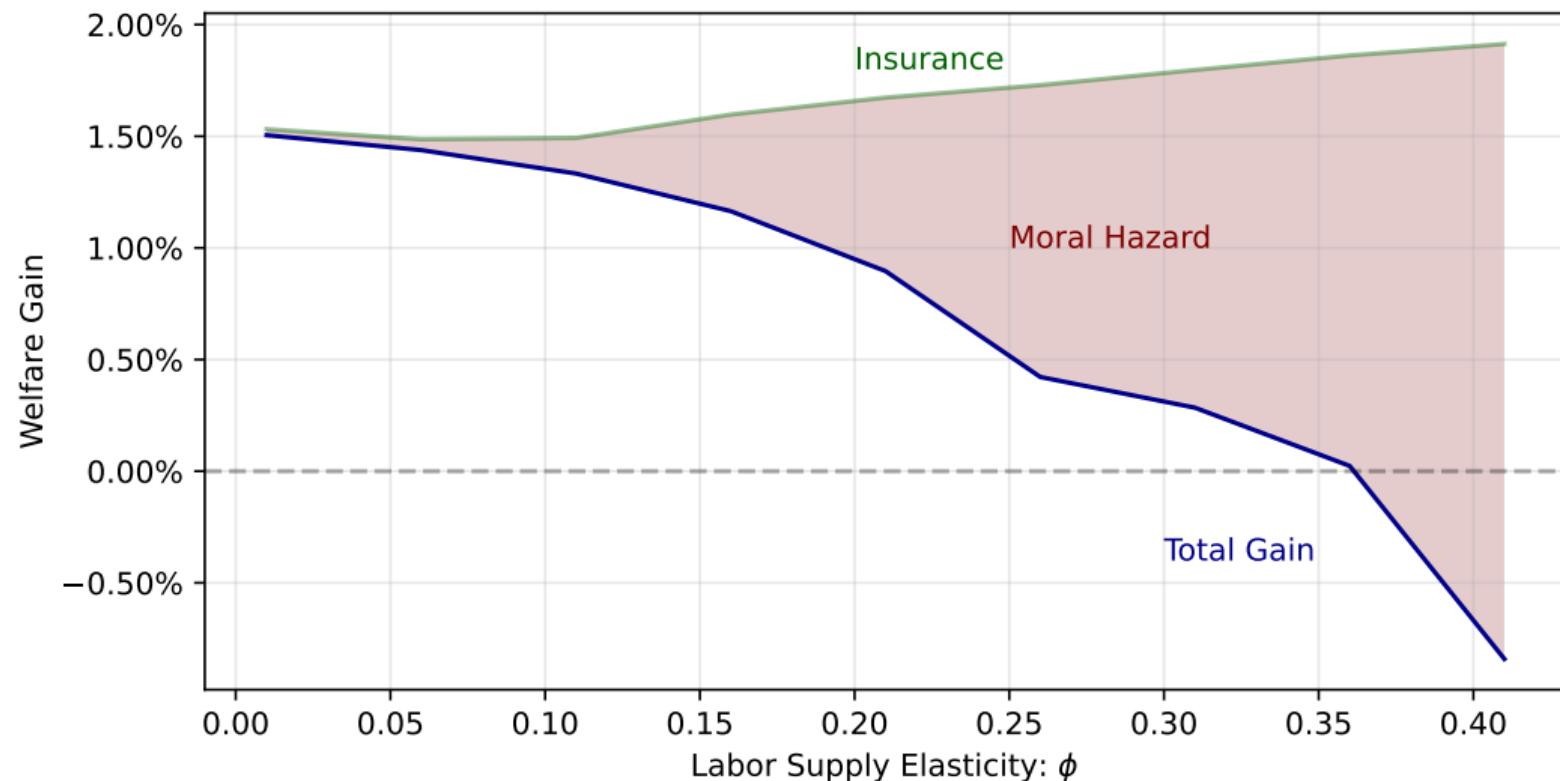
CONSTRAINED-OPTIMUM = 1.3% INCREASE IN LIFETIME CONSUMPTION



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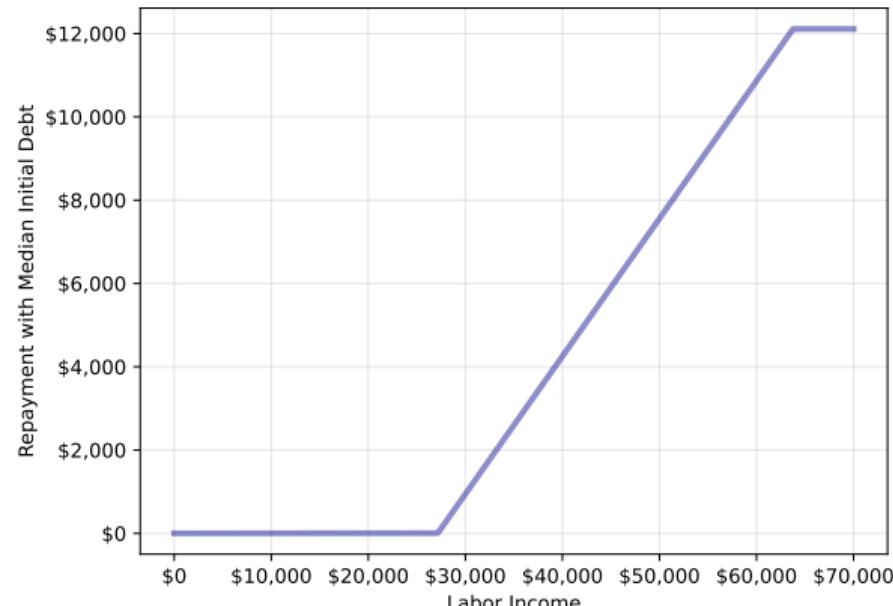
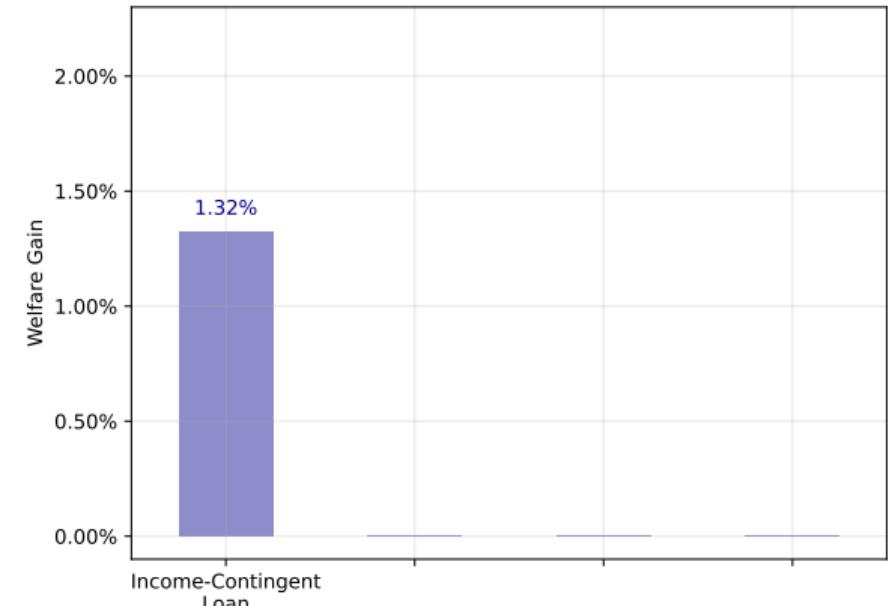


WELFARE GAIN IS POSITIVE AS LONG AS $\phi < 0.37$

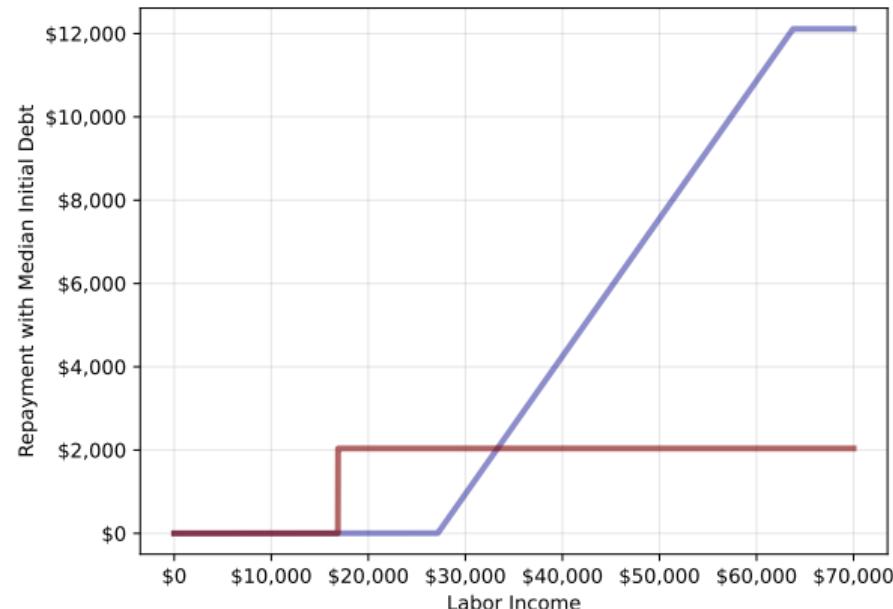
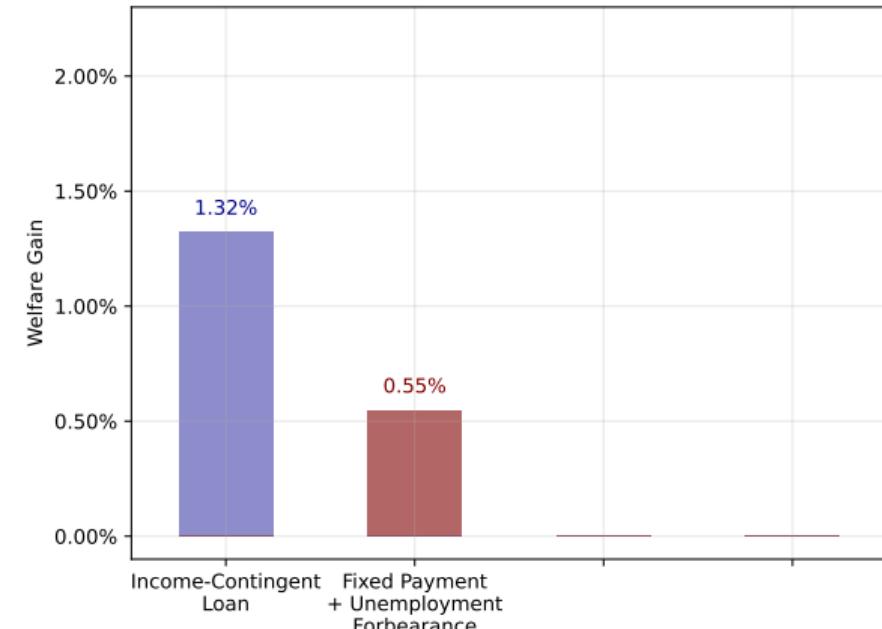


- ▶ Bunching at $\phi = 0.37$
- ▶ Contracts to Reduce MH
- ▶ Robustness: Frictions
- ▶ Robustness: RRA + EIS

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

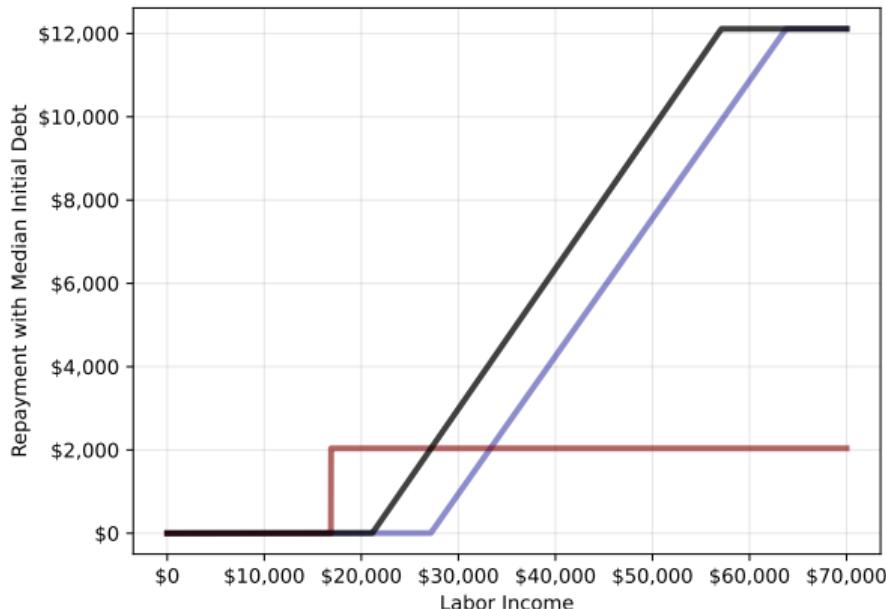
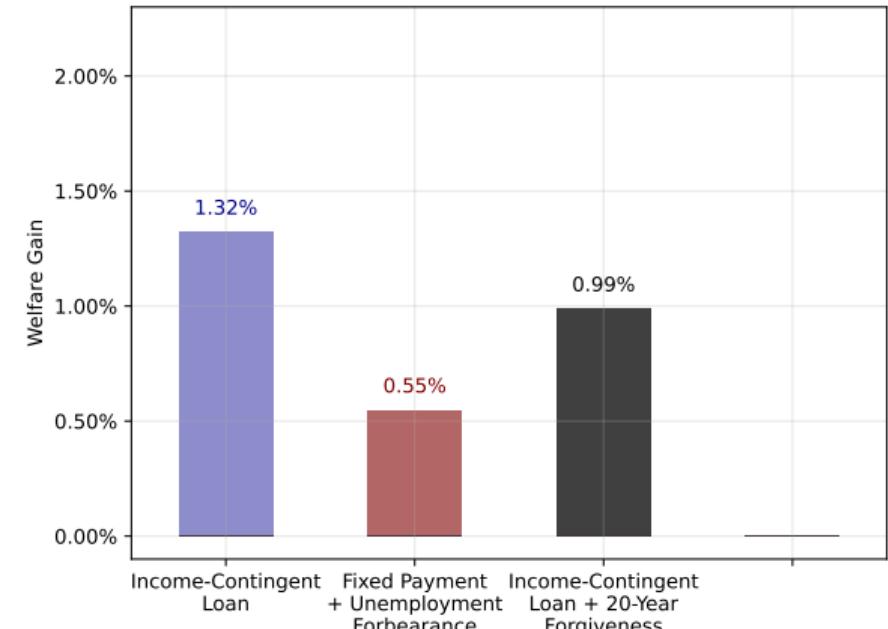


JUST PROVIDING FORBEARANCE GIVES SMALLER GAINS



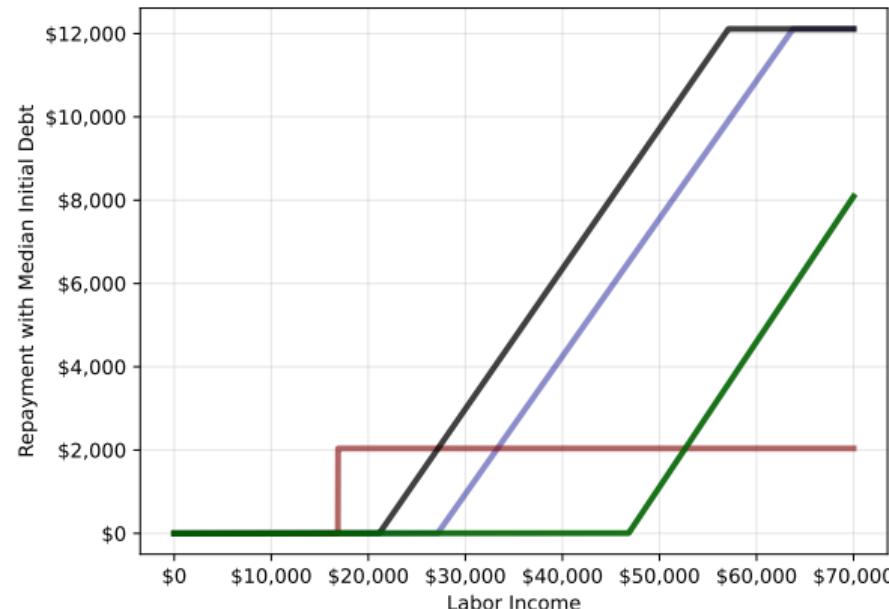
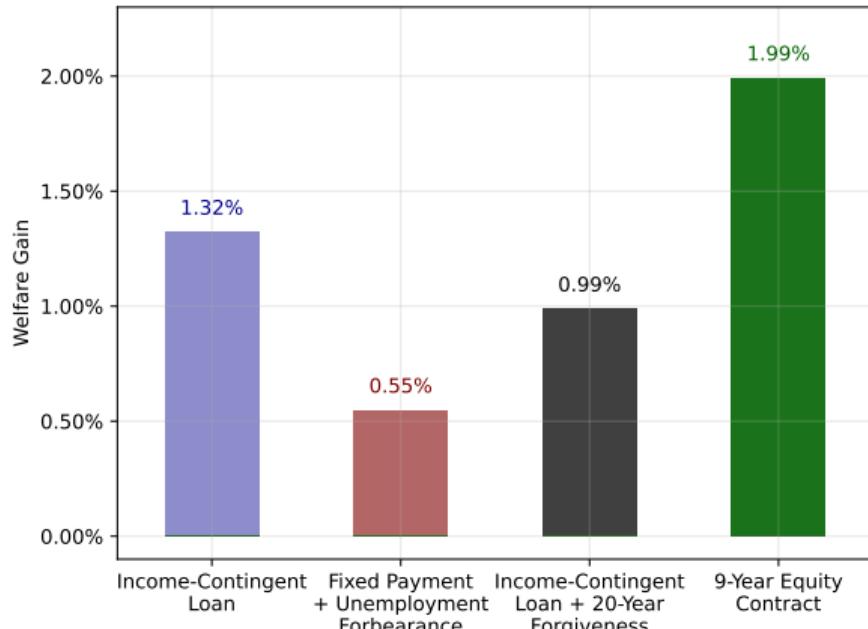
- **Benefit** of income-contingent loan: accelerate payments from high-income

ADDING FORGIVENESS REDUCES WELFARE GAINS



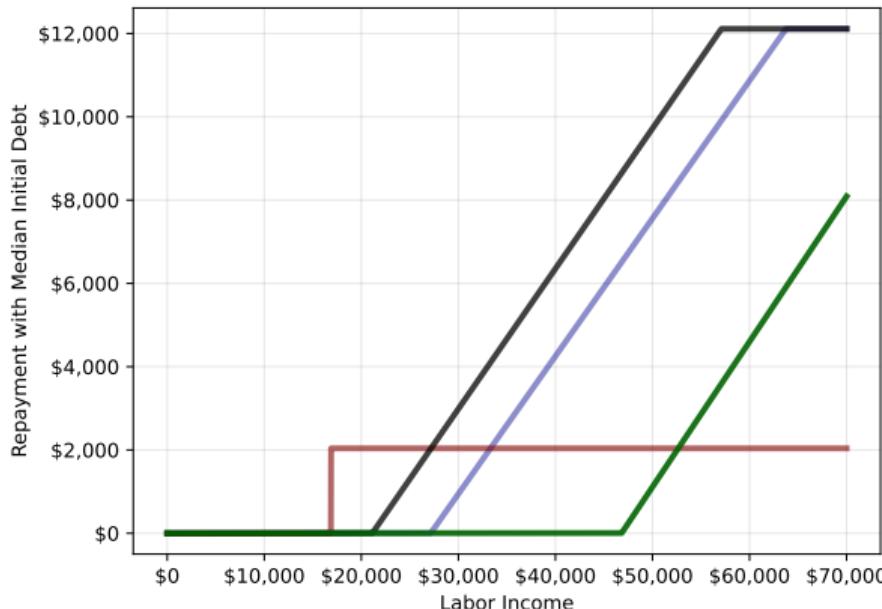
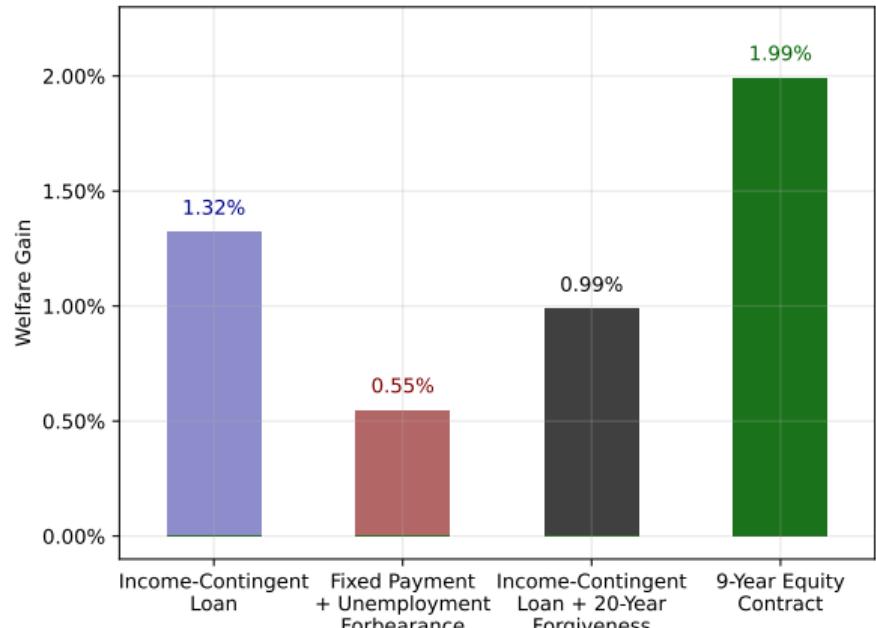
- **Costs** of forgiveness: transfer repayments to young and finite repayment horizon

EQUITY CONTRACT GIVES LARGER GAINS



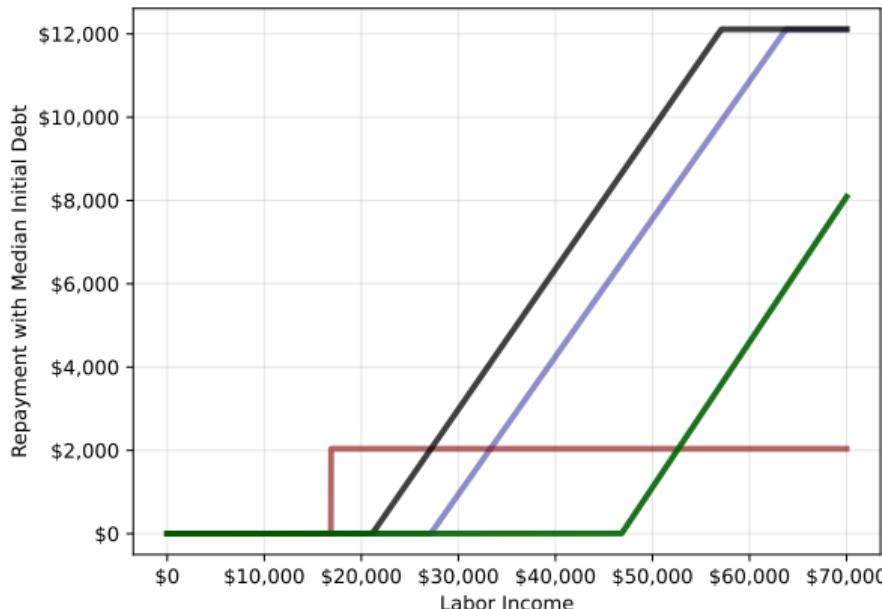
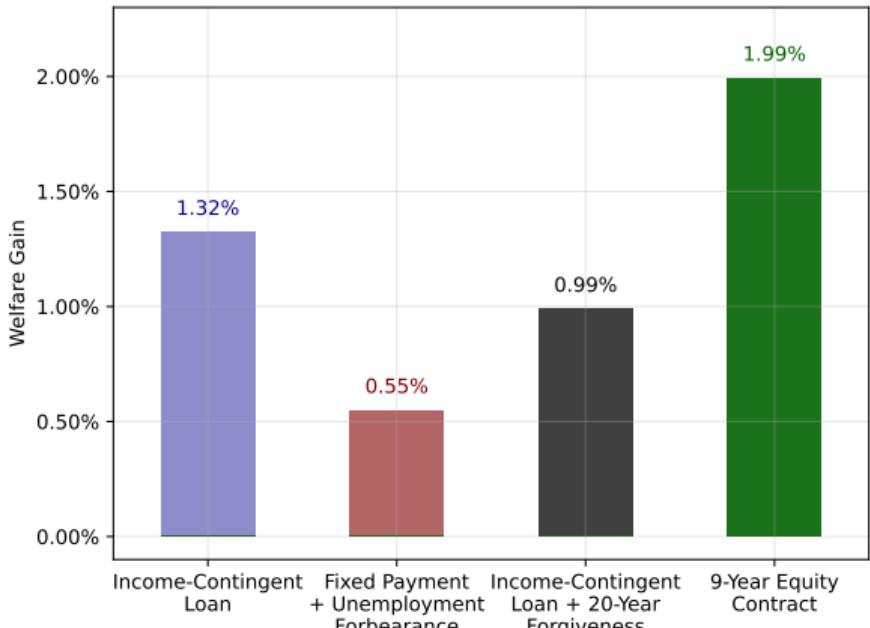
- **Benefit of equity:** uncapped payments from high-income \Rightarrow 70% higher threshold

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

► 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 debt restructuring
 - 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!

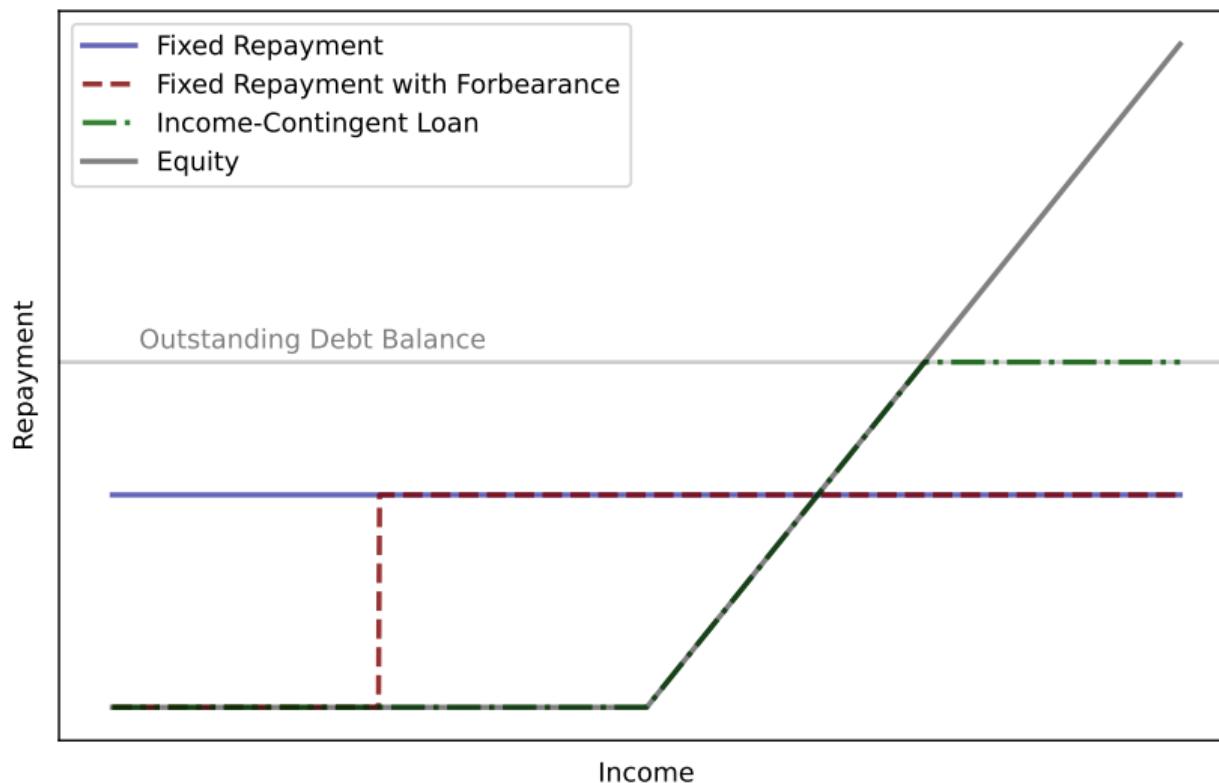
www.timdesilva.me

tdesilva@stanford.edu

APPENDIX

START OF APPENDIX

ILLUSTRATION OF DIFFERENT REPAYMENT CONTRACTS

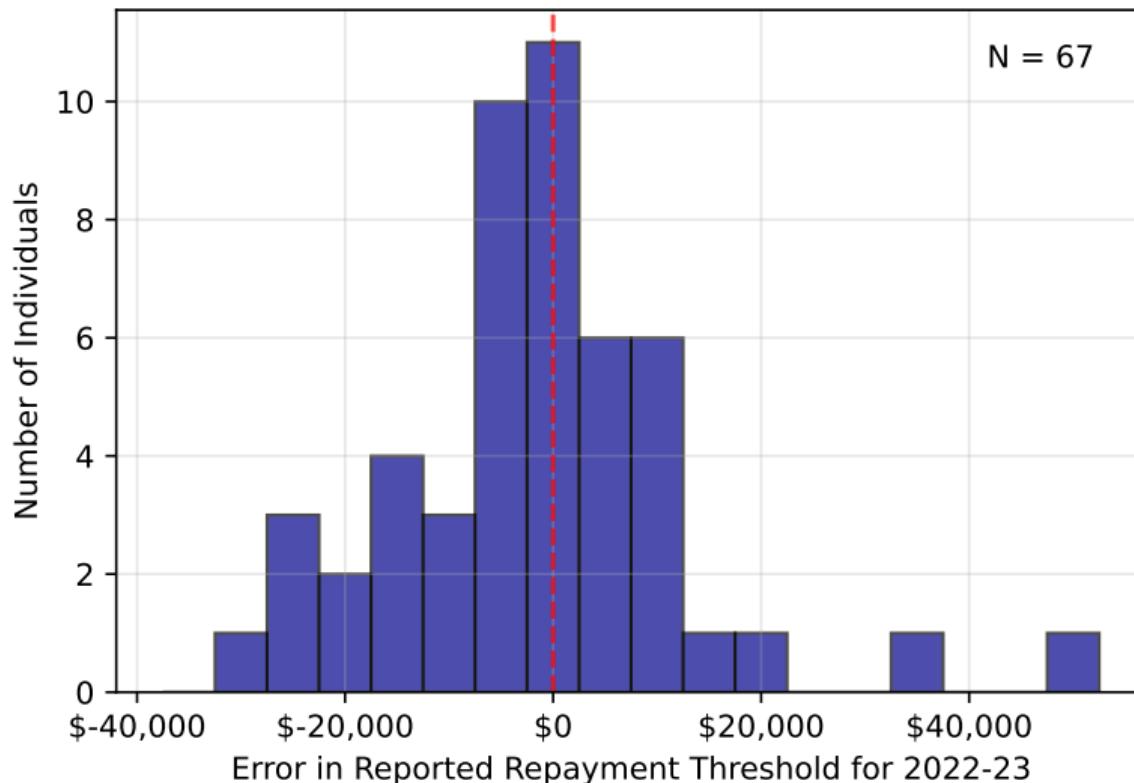


◀ Back: Introduction

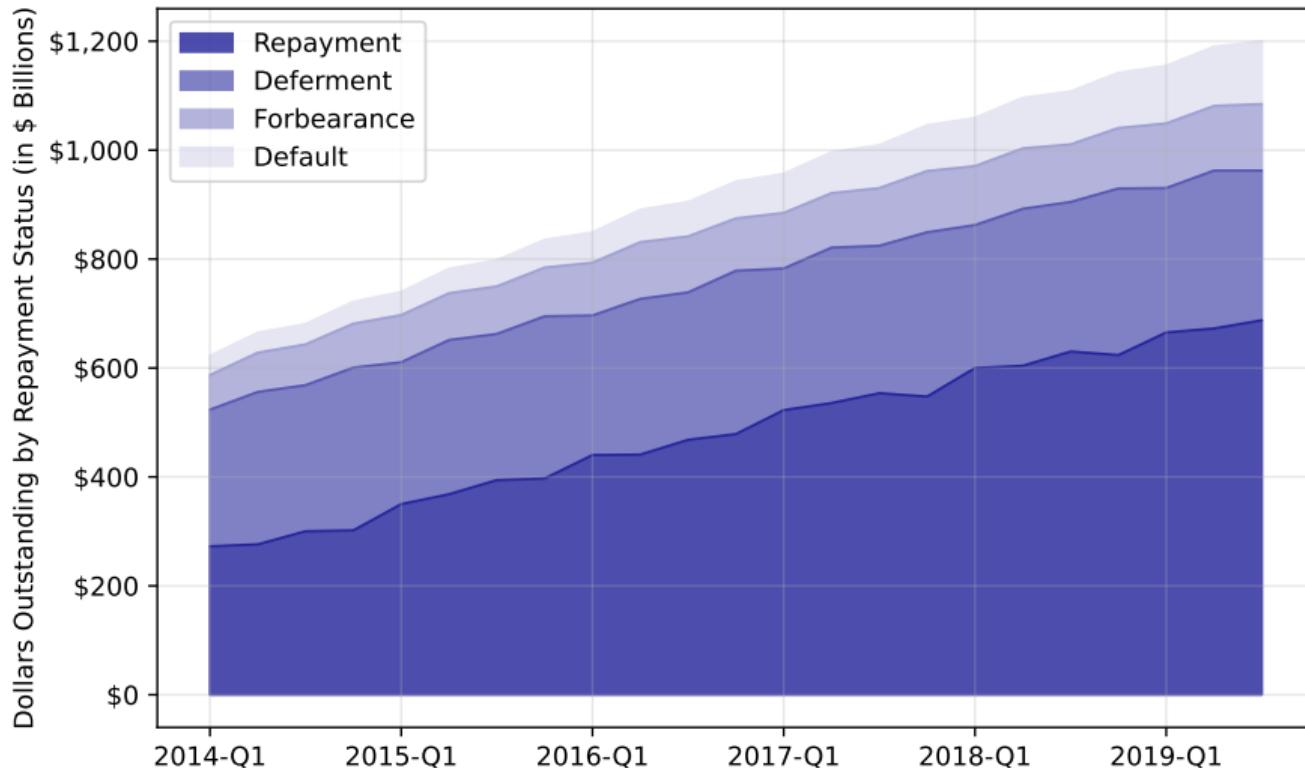
◀ Back: This Paper

◀ Back: Main Results

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

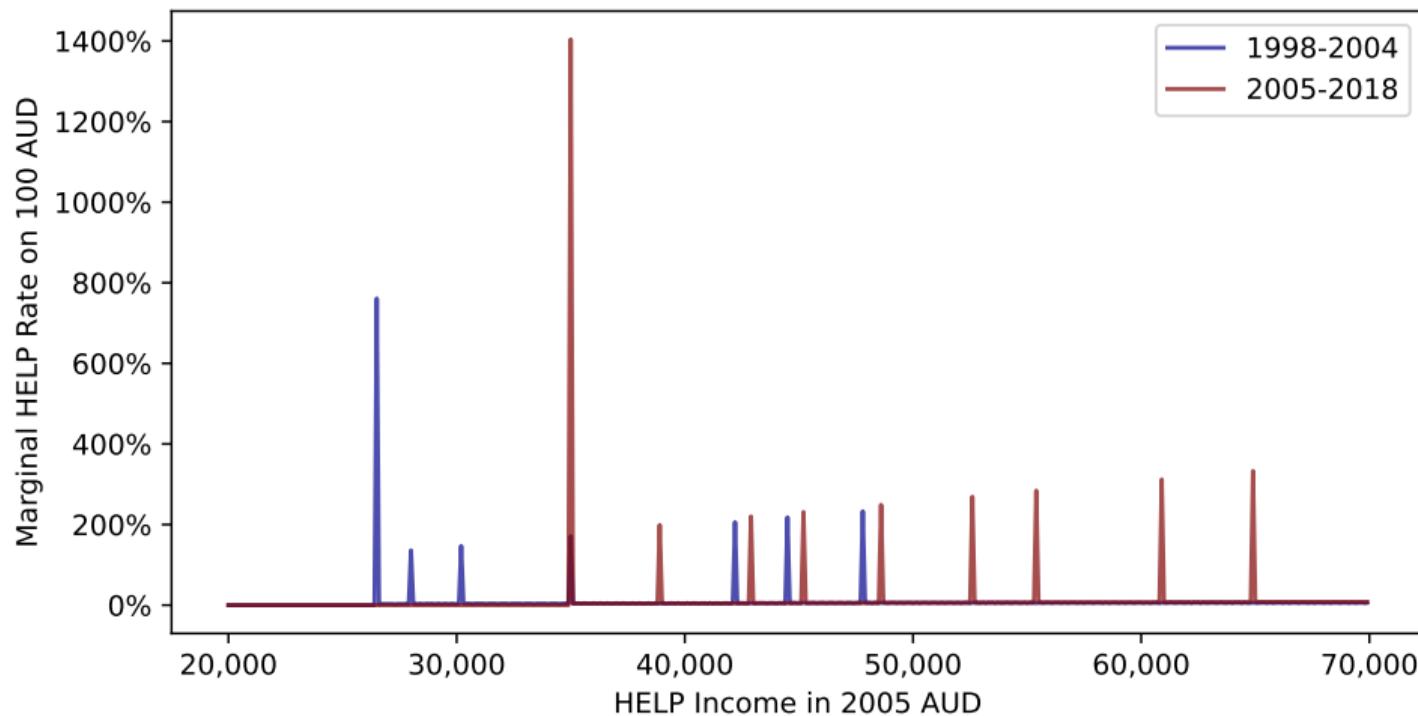
DIFFERENCES BETWEEN AUSTRALIA AND US: STATISTICS

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](#)

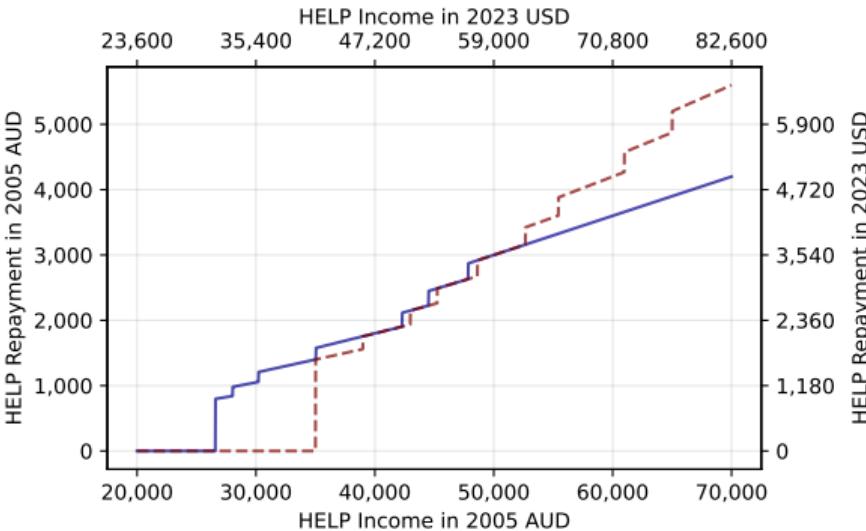
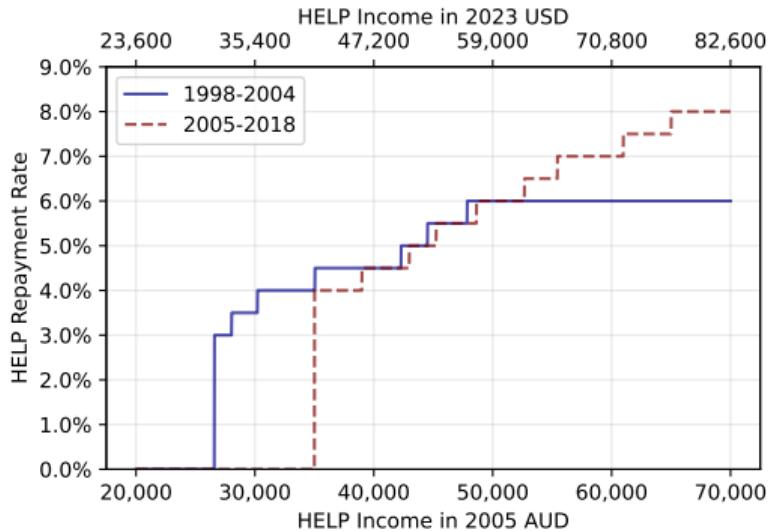
[◀ Back: Differences](#)

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



Save

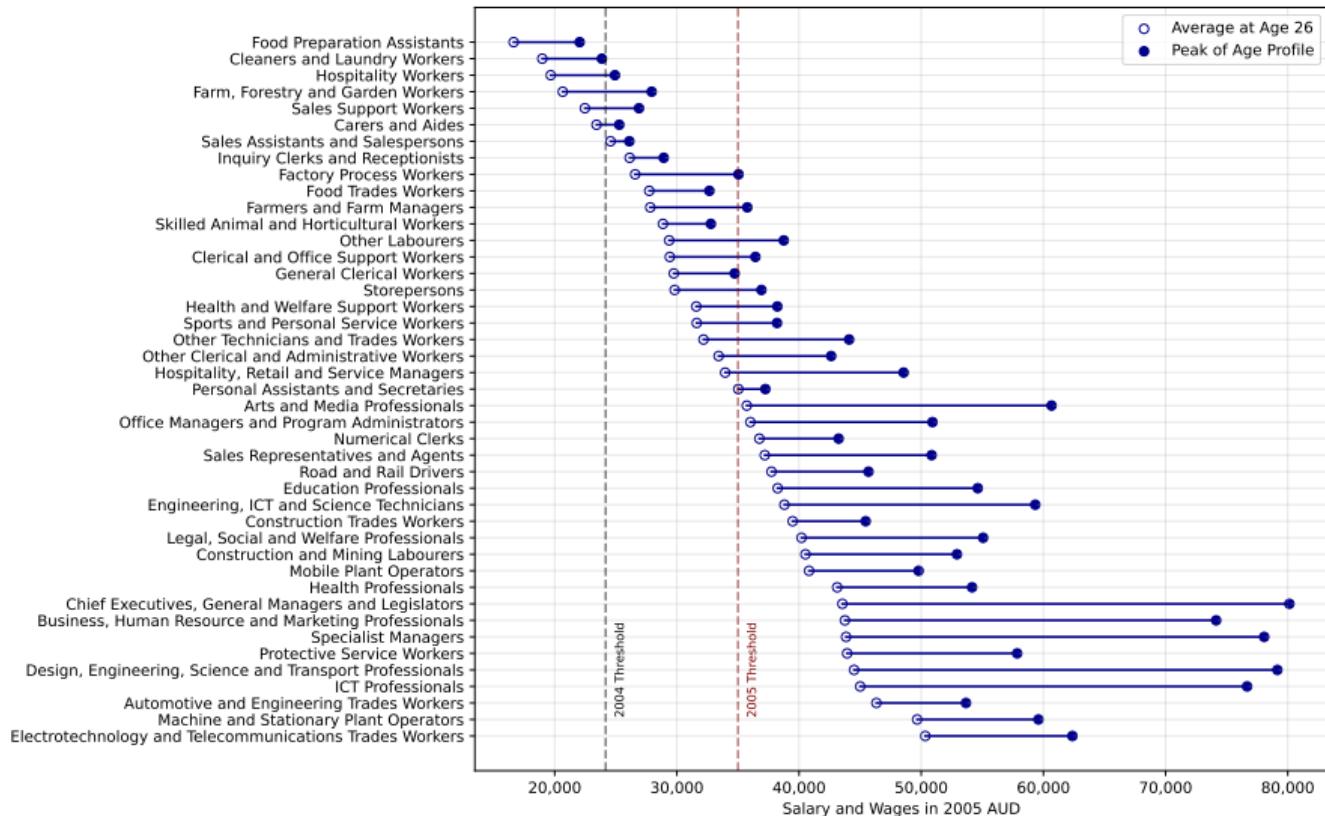


Share

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

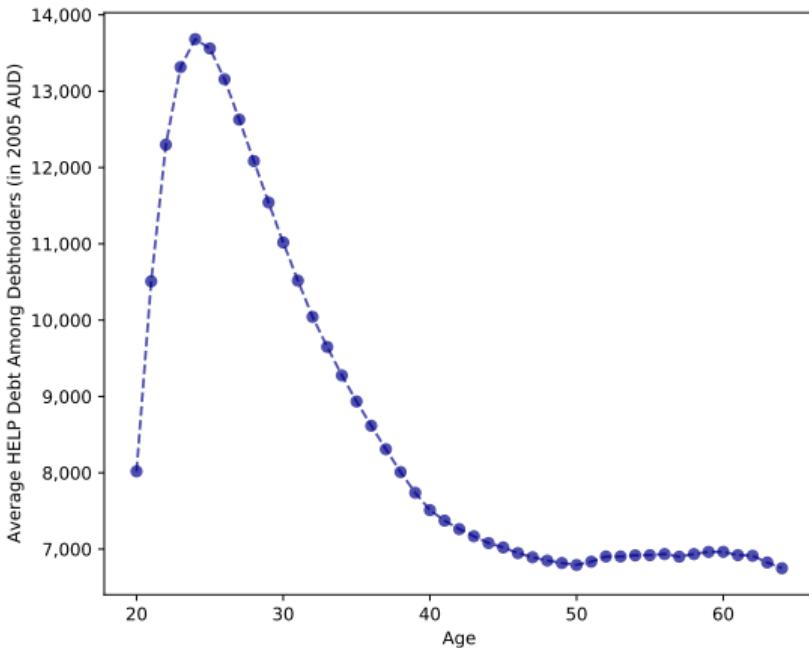
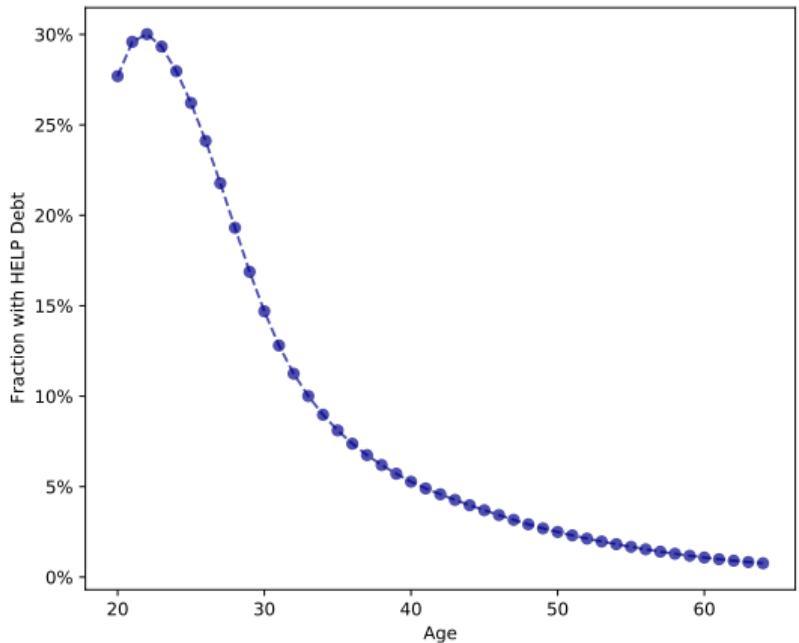
◀ Back: Table

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

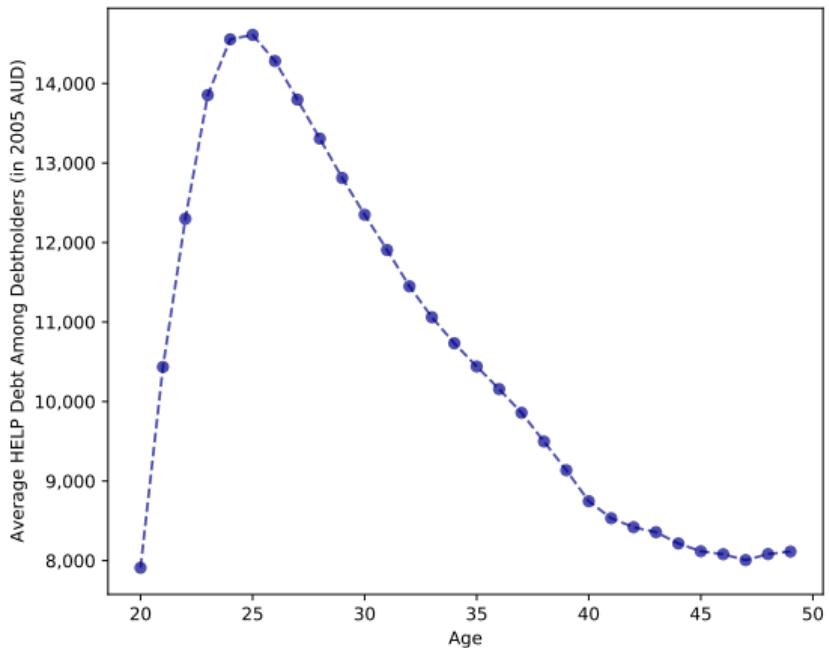
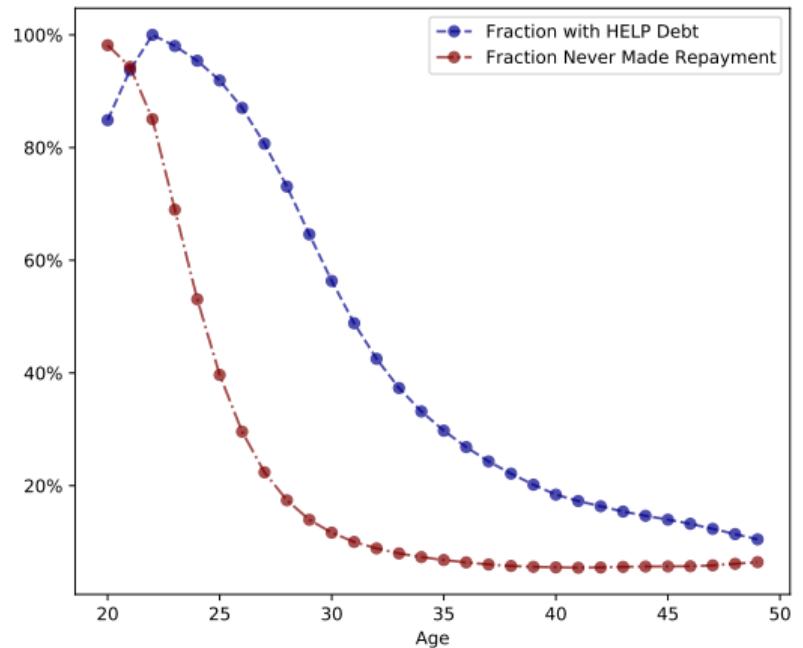
◀ Back

DEBT BALANCES BY AGE



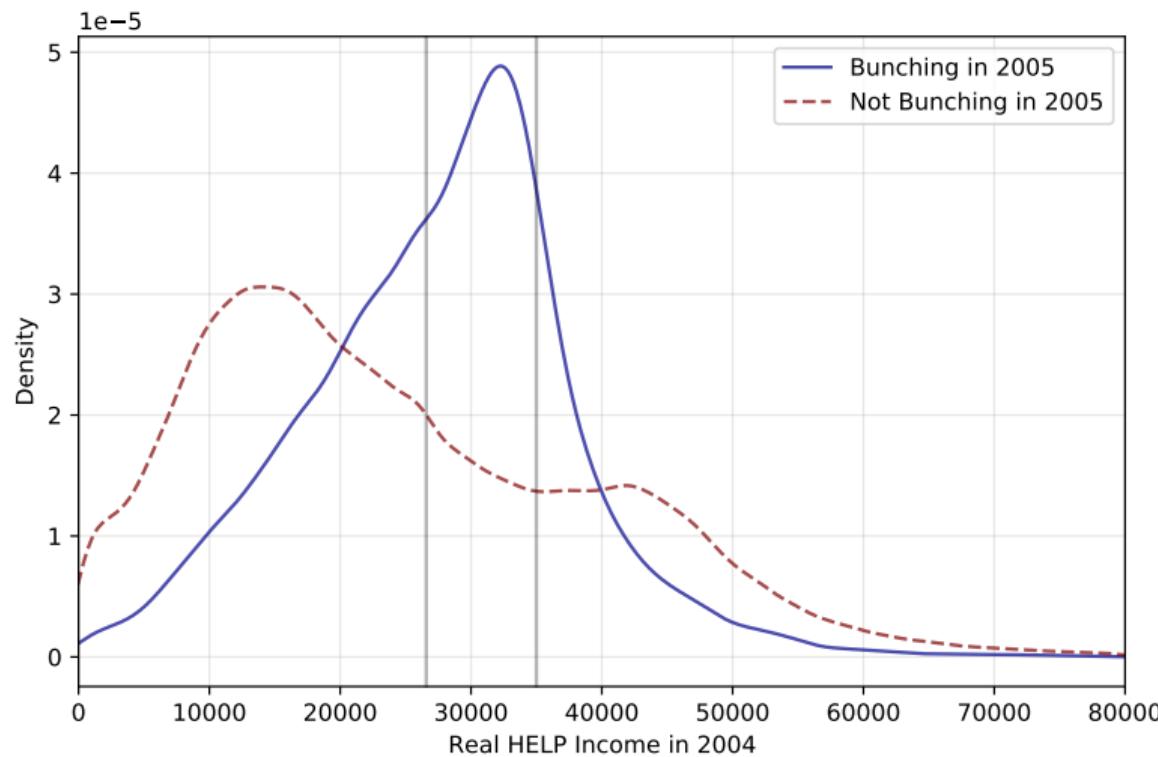
◀ Back

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



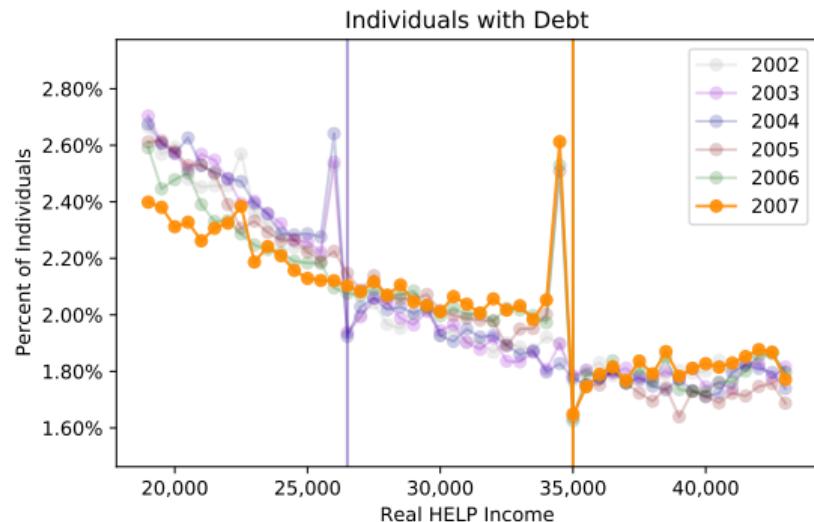
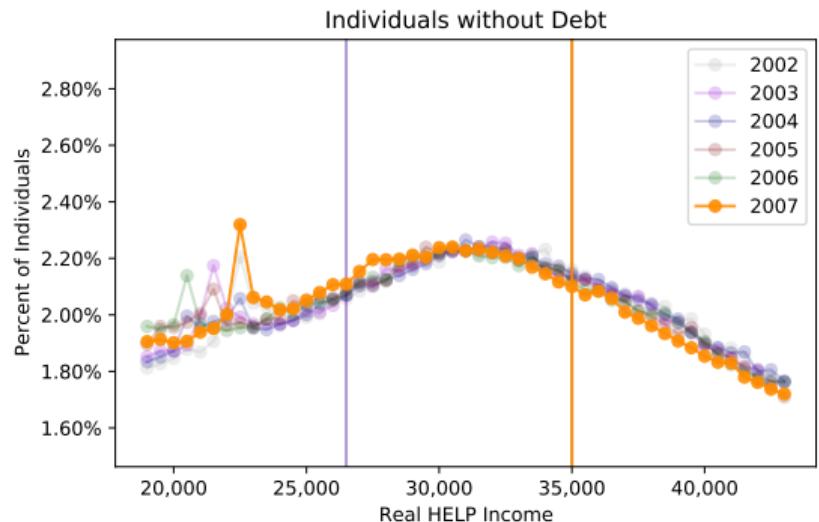
◀ Back

NEW BUNCHING COMES FROM BETWEEN OLD AND NEW THRESHOLDS



◀ Back

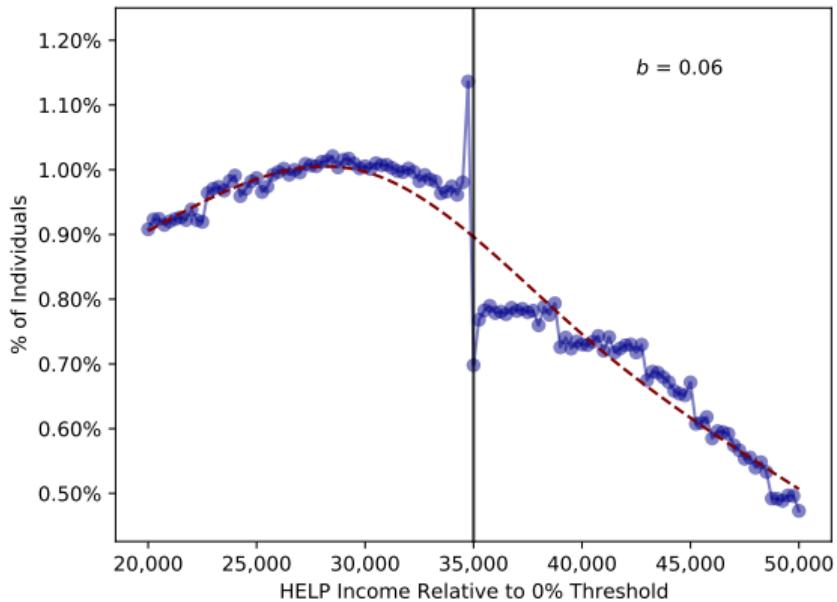
No BUNCHING AT REPAYMENT THRESHOLD FOR NON-DEBTHOLDERS



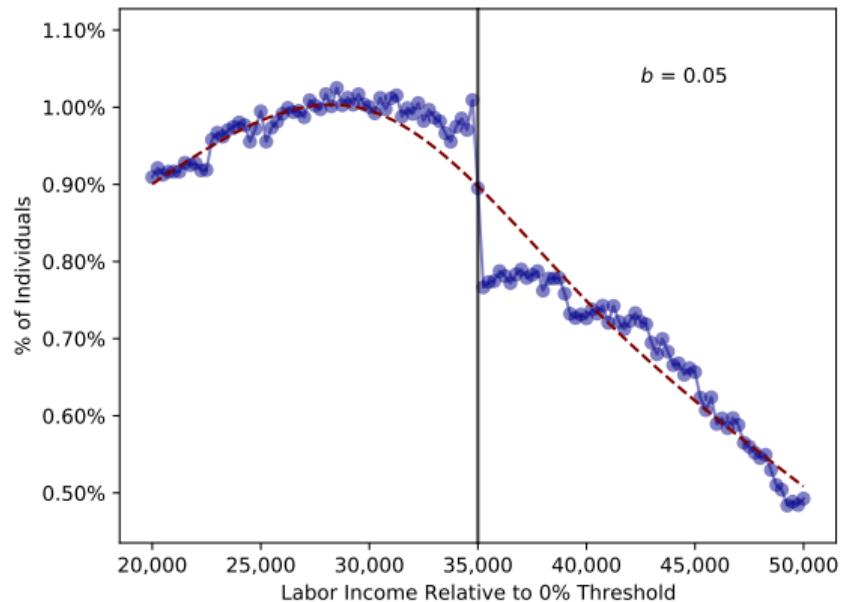
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BUNCHING IN LABOR INCOME = 83% OF BUNCHING IN HELP INCOME

HELP Income

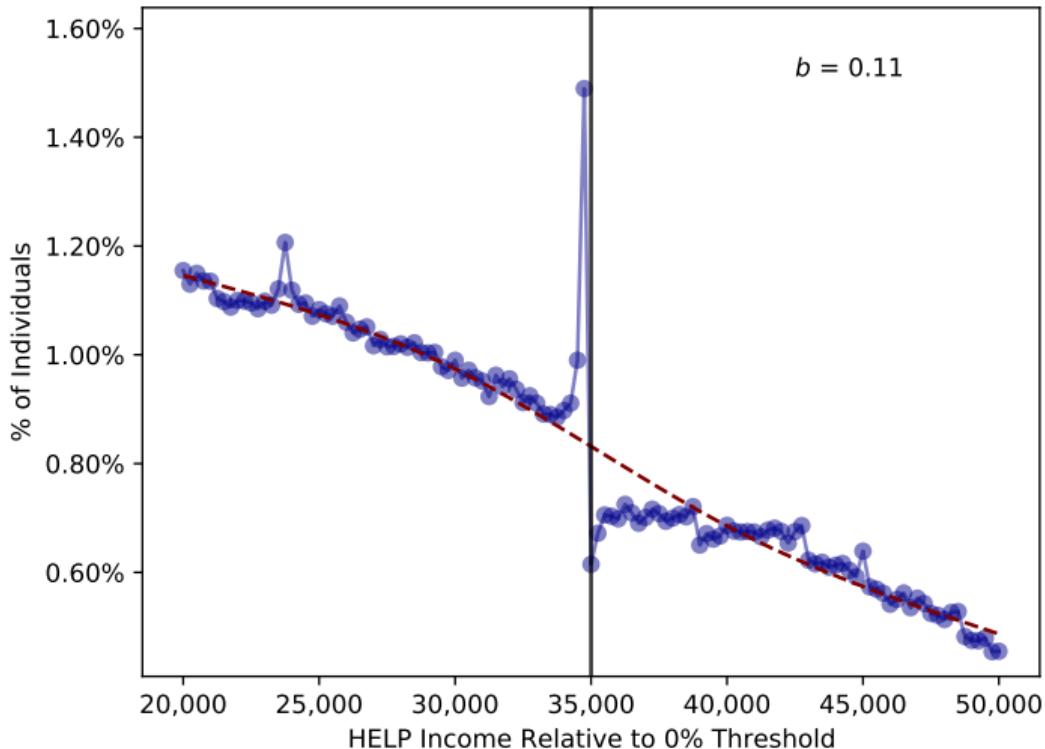


Labor Income



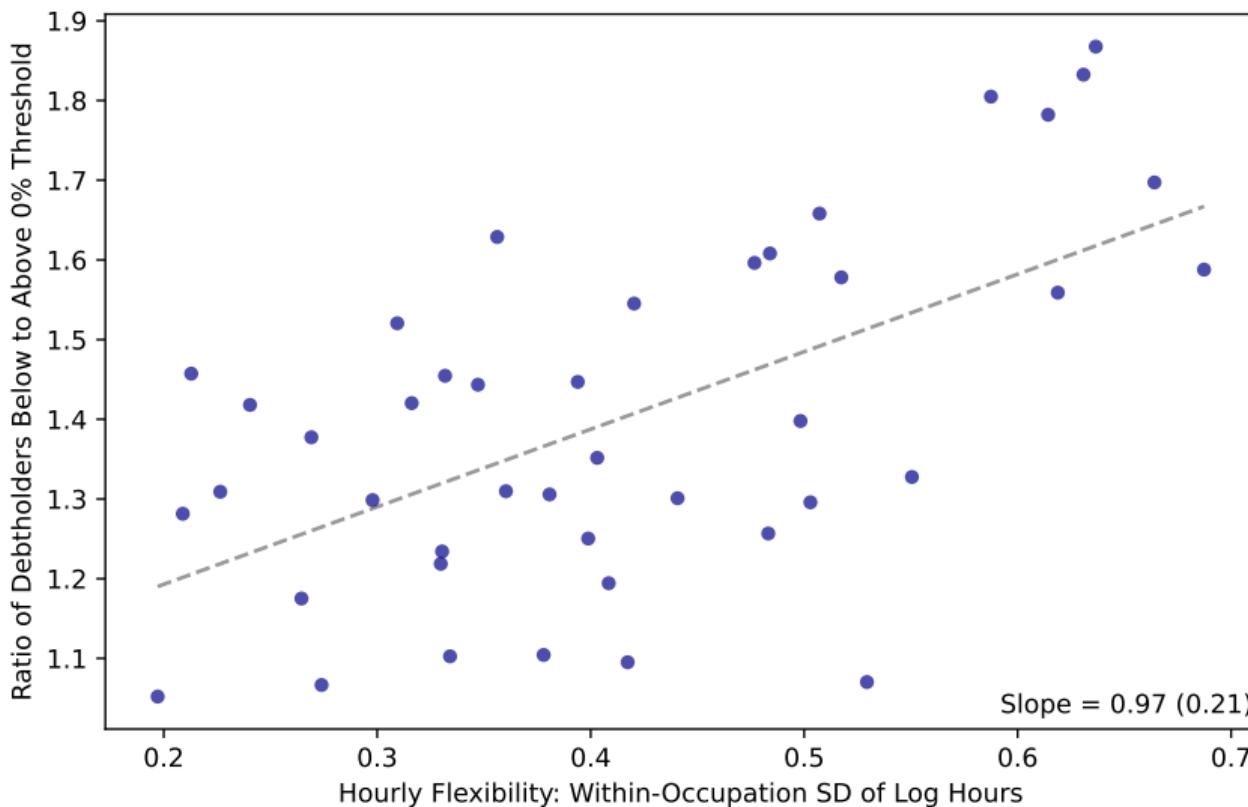
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BUNCHING AT THRESHOLD IS LARGER THAN AT TAX KINK: 2016



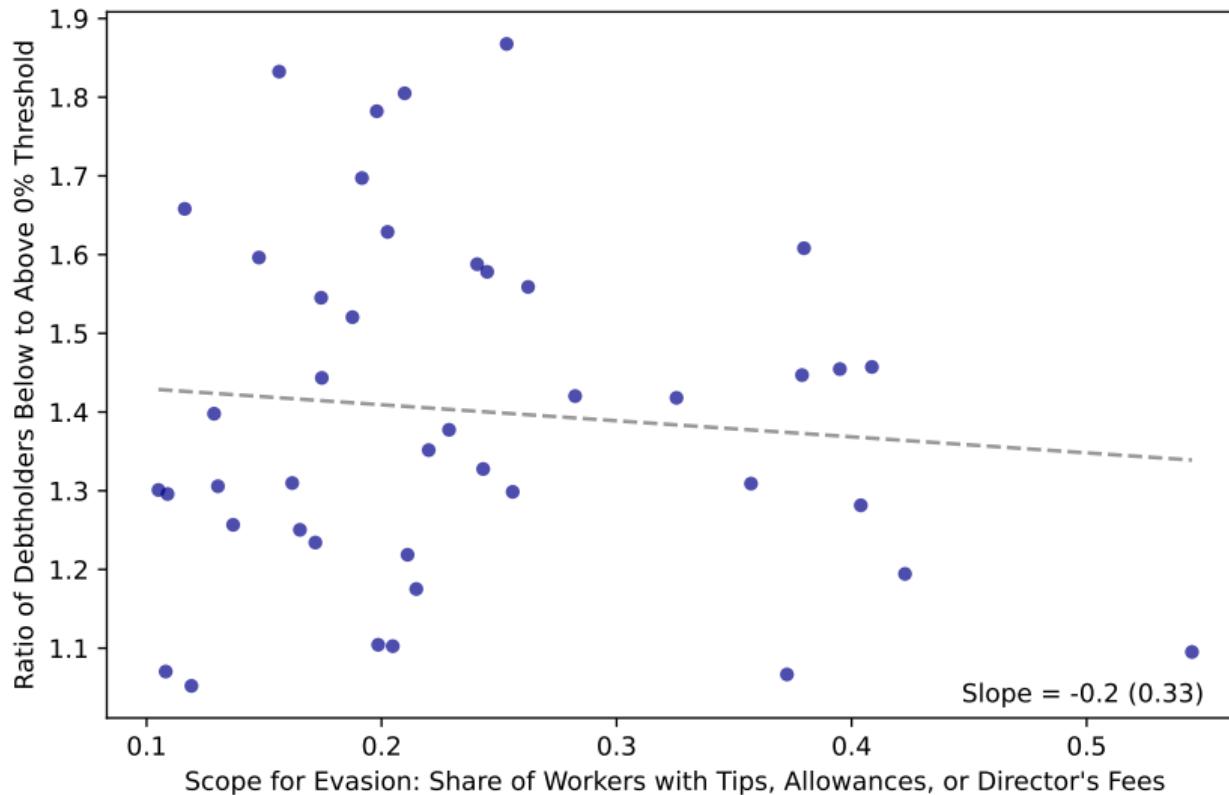
◀ Back

ALTERNATIVE MEASURE OF HOURLY FLEXIBILITY



◀ Back

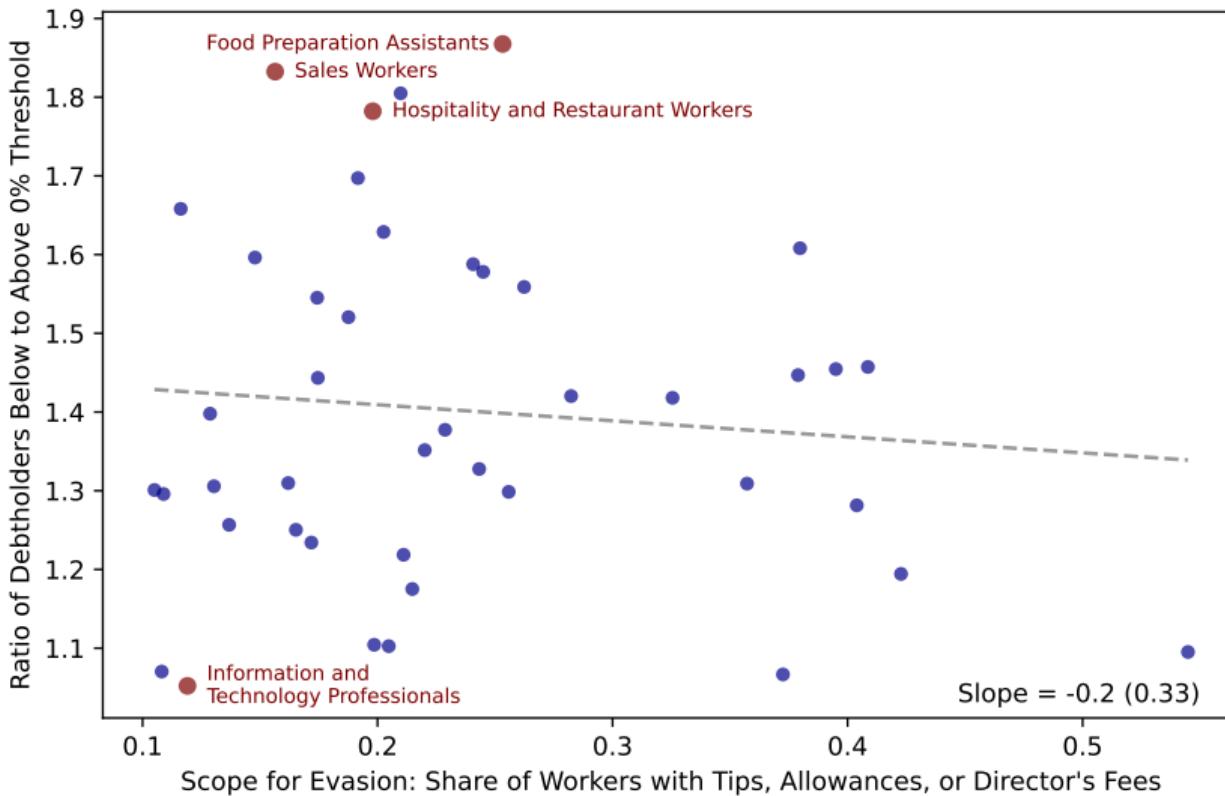
BUNCHING UNCORRELATED WITH MEASURE OF EVASION



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

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

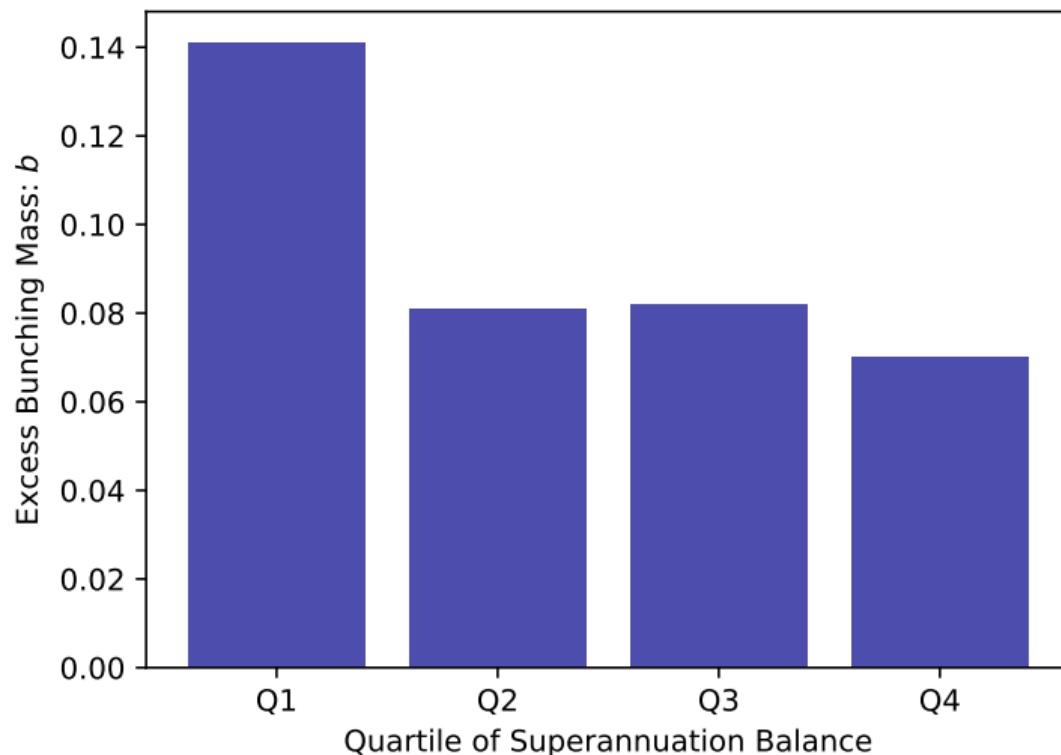
- Bunching statistic calculated as in prior literature Chetty et al. 2011, Kleven-Waseem 2013

- 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
-

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

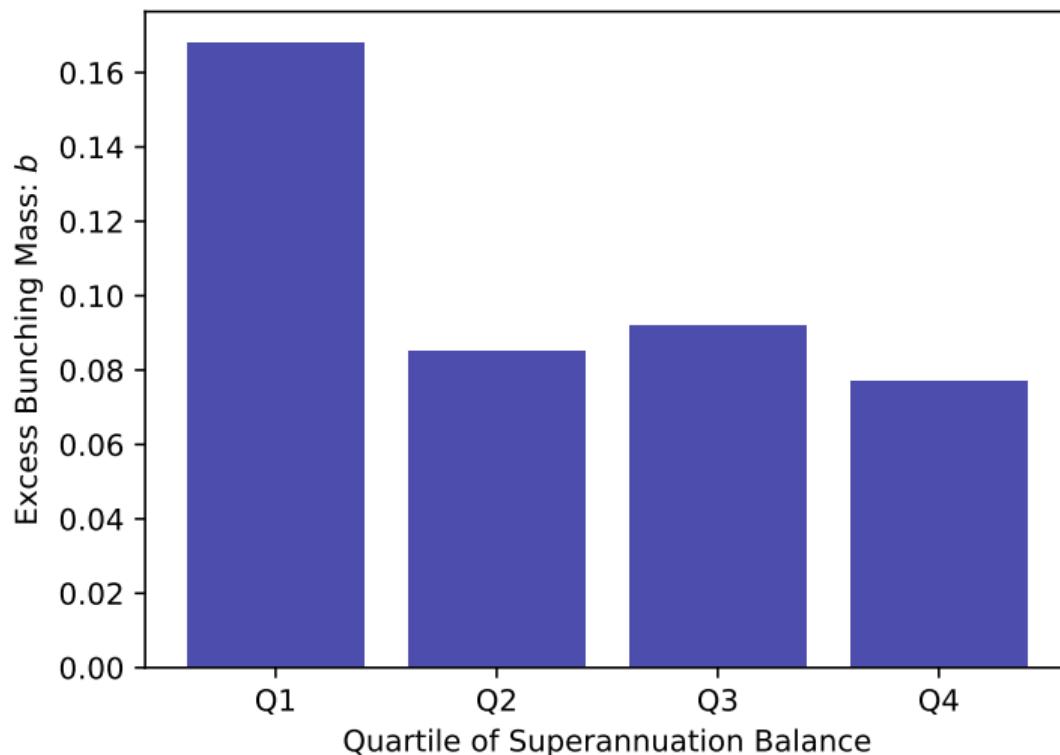
- $b = 0.1 \Rightarrow$ 10% more people below threshold than would be absent discontinuity
 - Note: normalization makes b comparable across distributions of different shapes
- Sample:** All debtholders age 20 to 64 pooled across 2005 to 2018
 - Income deflated to 2005 so 0% threshold constant in real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

BUNCHING DECREASES WITH SUPERANNUATION BALANCES



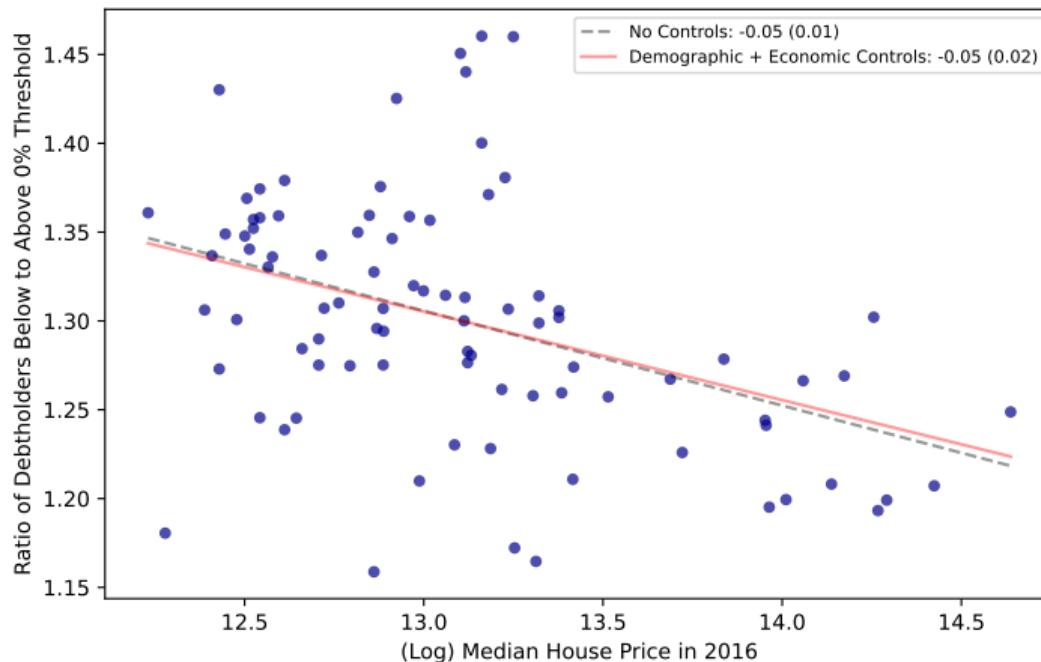
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BUNCHING HETEROGENEITY BY SUPER WEALTH: AGES 20-29



◀ Back

LESS BUNCHING IN REGIONS WITH MORE HOUSING WEALTH



◀ Back

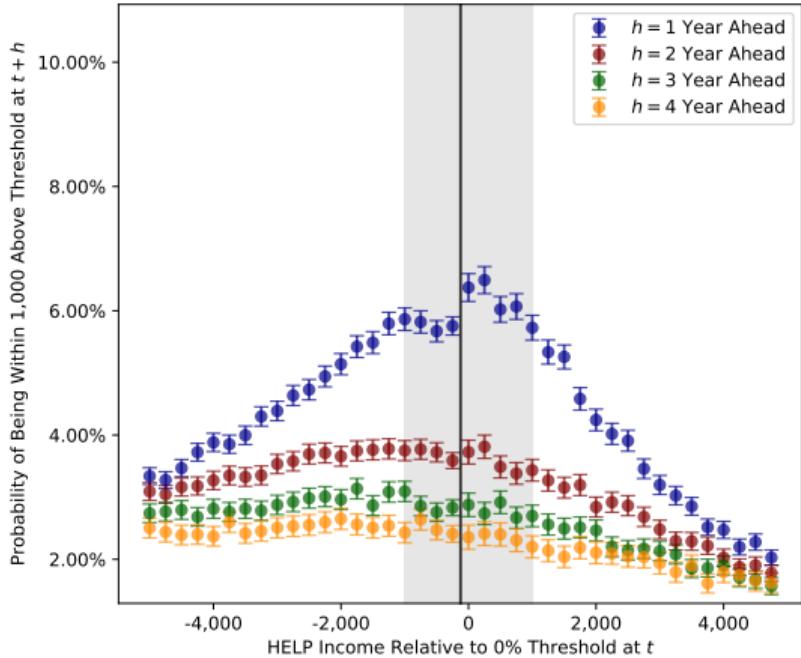
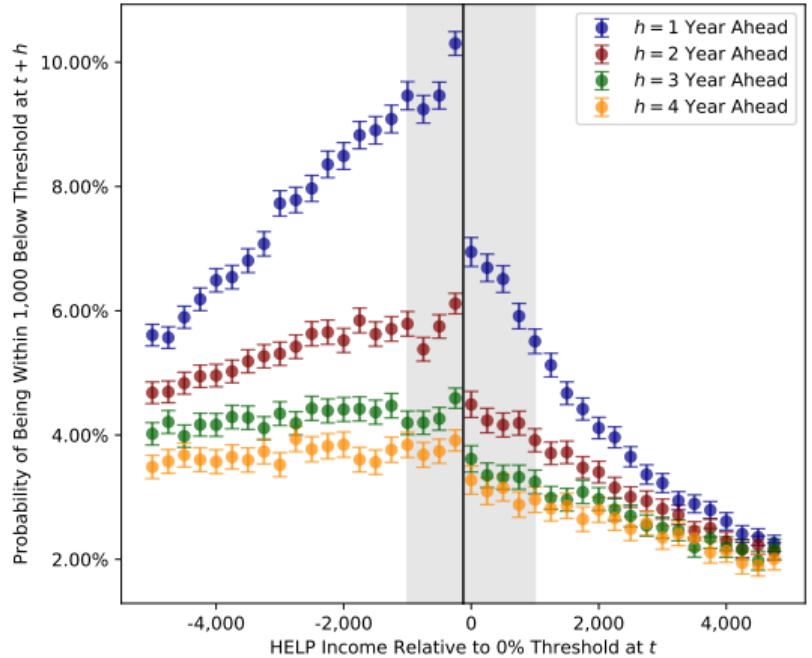
ADDITIONAL EMPIRICAL RESULTS

- ① **Persistence** of bunching below threshold lasts around three years 
- ② **Long-run**: income of “bunchers” similar to “non-bunchers” after two years 
- ③ No discontinuity in probability of **switching occupations** around threshold 
- ④ Limited heterogeneity in bunching with household **demographics** 
 - Caveat: no extensive margin responses, which can vary across groups Saez et al. 2012
- ⑤ Limited evidence of bunching coming from **firm responses** (as in Chetty et al. 2011) 
- ⑥ 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 ⇒ less avoidance **opportunities** Slemrod-Yitzhaki 2002

 Back: Hours

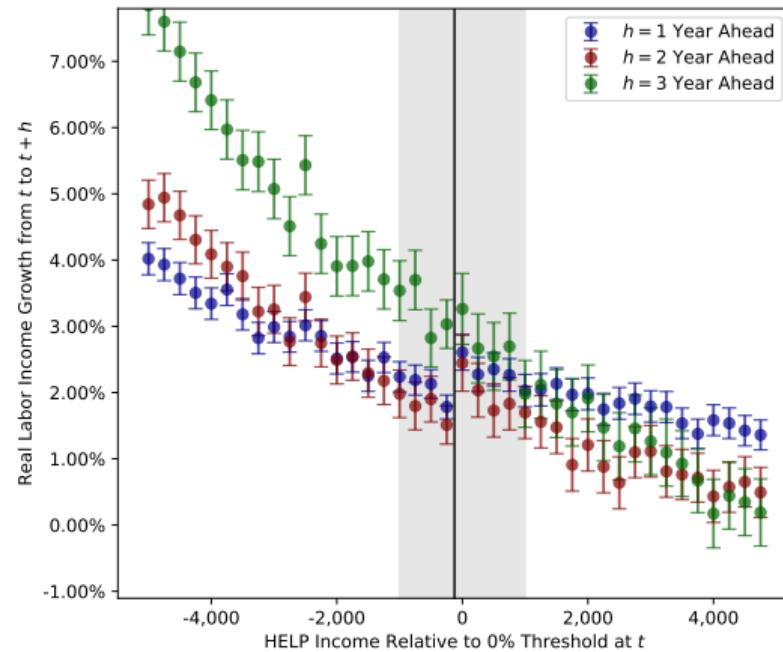
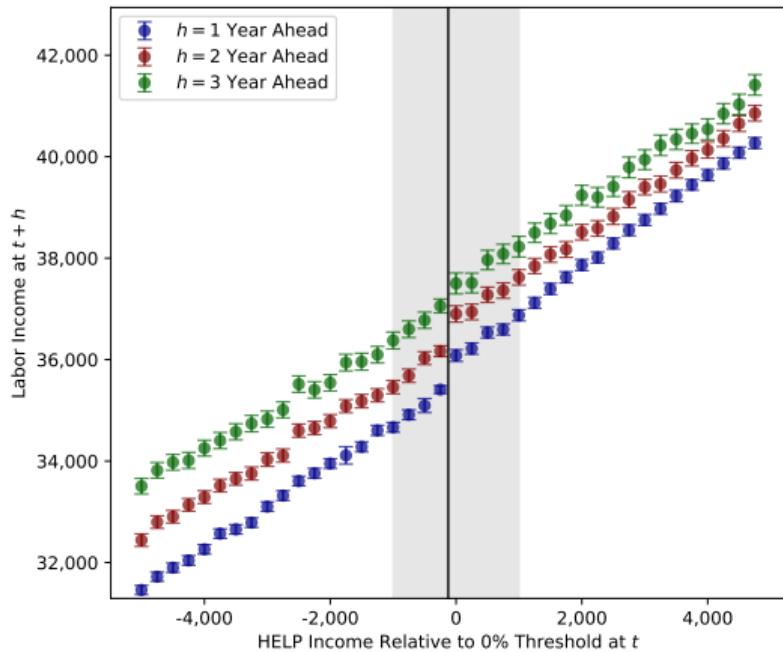
 Back: Summary

PERSISTENCE OF BUNCHING LASTS AROUND THREE YEARS



◀ Back

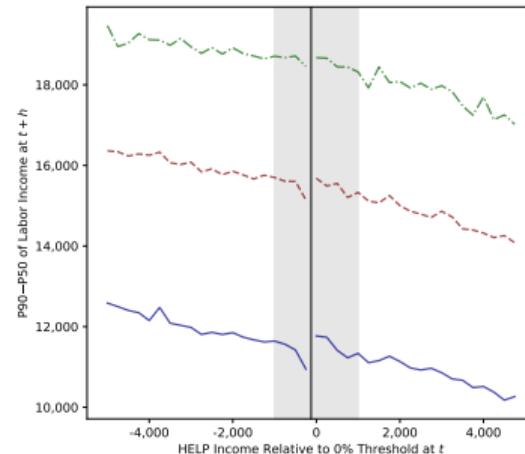
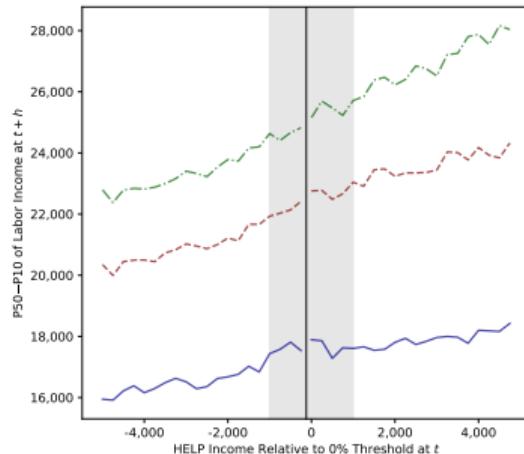
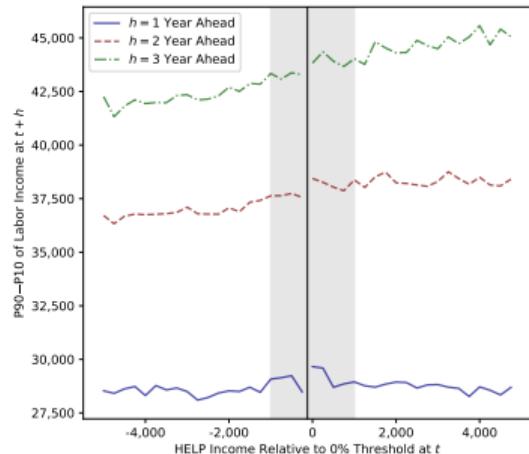
LIMITED EVIDENCE OF DYNAMIC COST TO BUNCHING



▶ Distribution

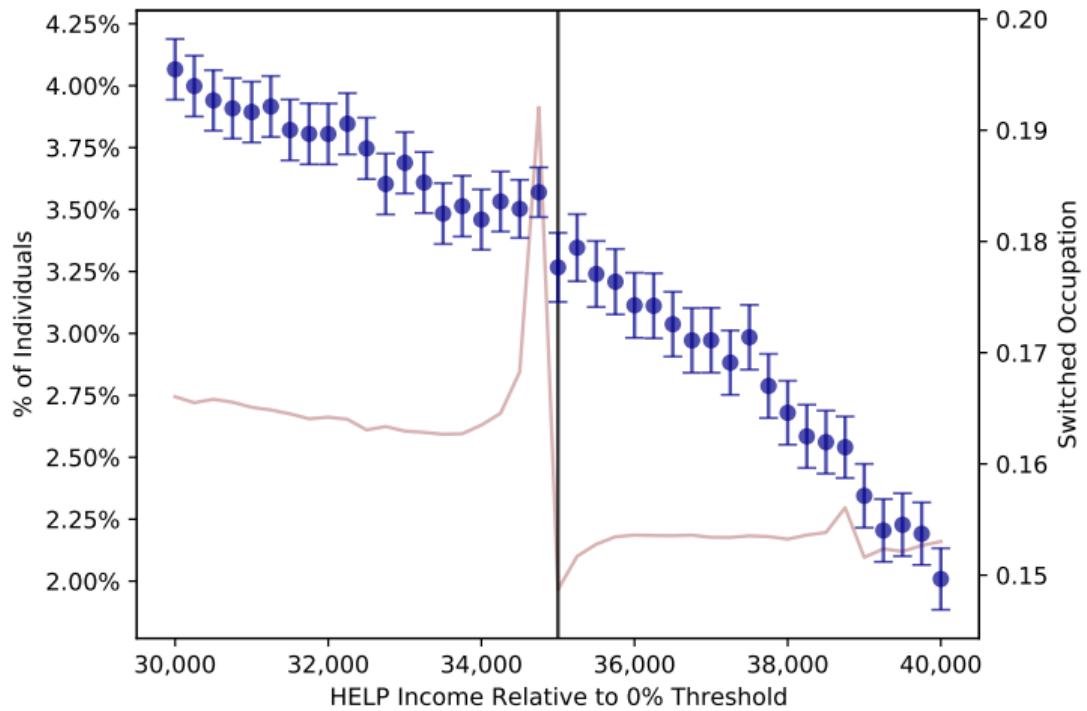
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LITTLE DIFFERENCE IN DISTRIBUTION OF FUTURE INCOME



◀ Back

No Discontinuity in the Probability of Switching Occupations



◀ Back

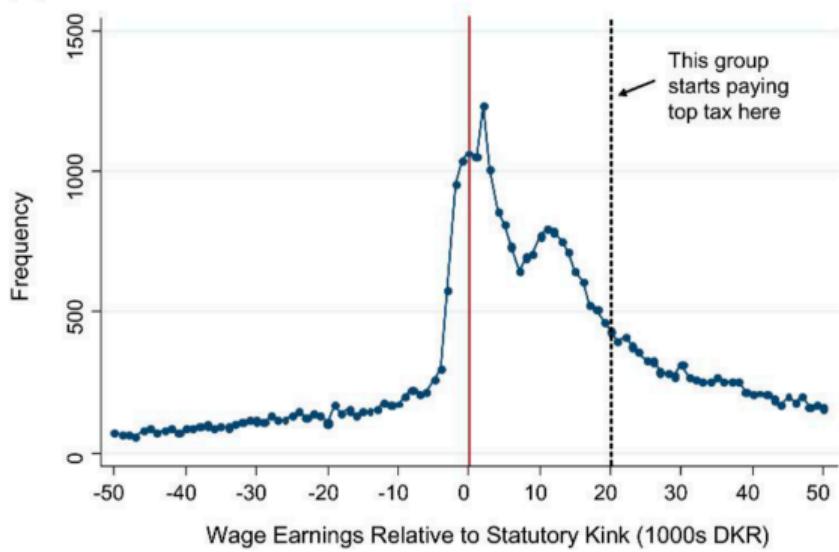
DEMOGRAPHIC HETEROGENEITY IN BUNCHING

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

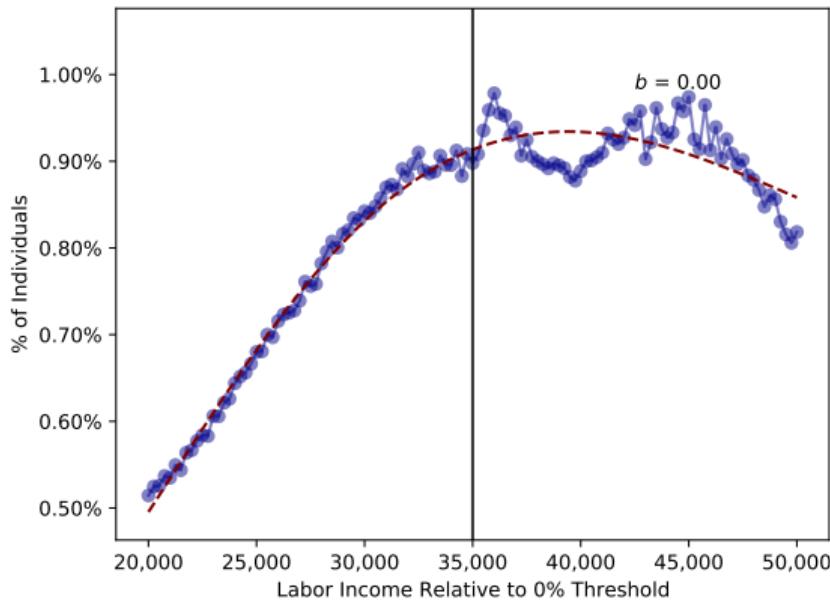
◀ Back

CHETTY ET AL. (2011) TEST OF FIRM RESPONSES

Chetty et al: Teacher Wages



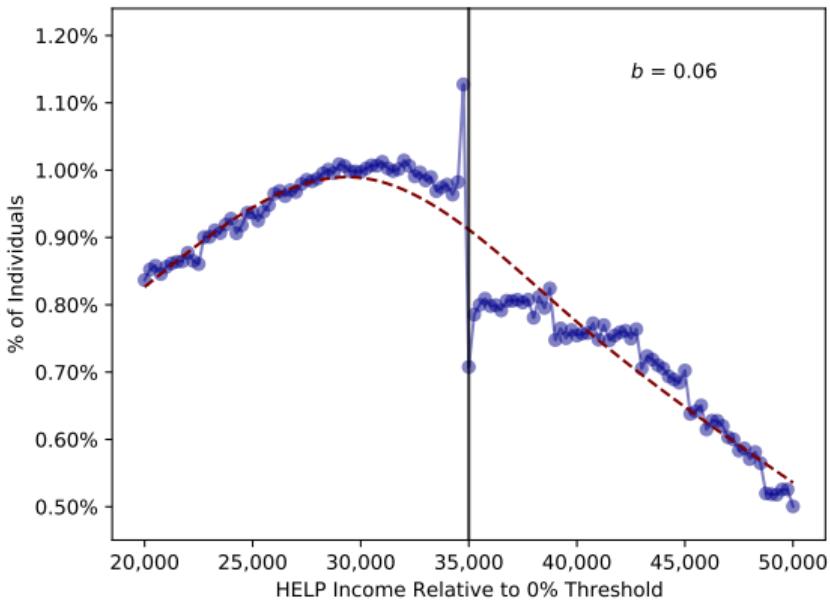
Borrower Labor Income



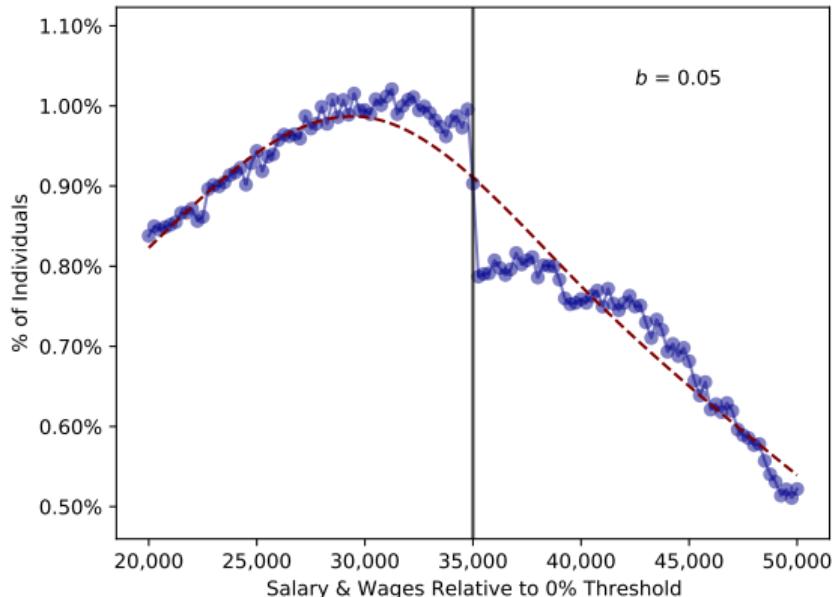
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BUNCHING IN DISTRIBUTION OF SALARY AND WAGES

HELP Income



Salary and Wages



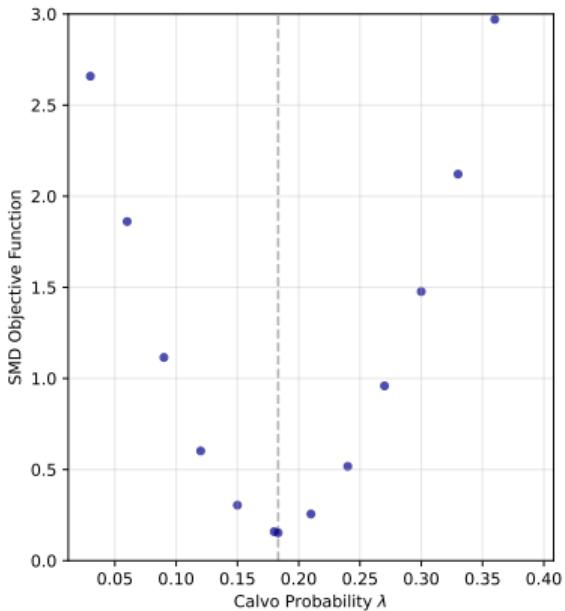
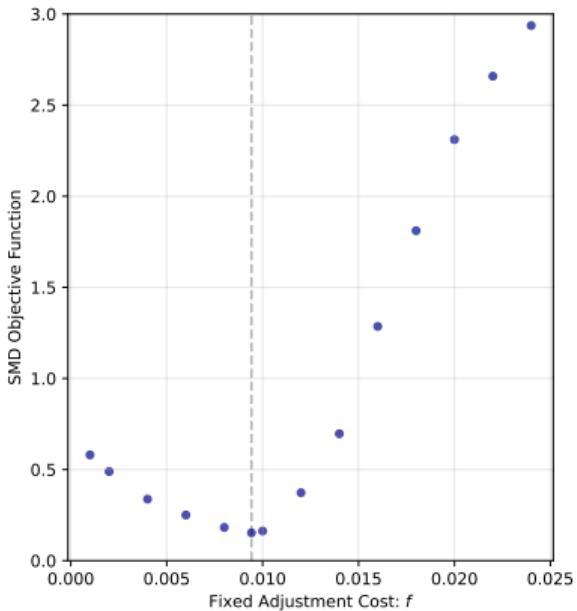
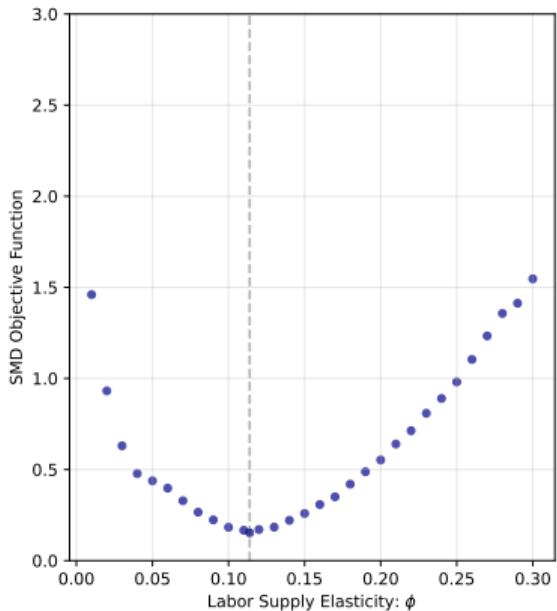
[◀ Back](#)

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

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SMM OBJECTIVE IS SMOOTH IN LABOR SUPPLY PARAMETERS



◀ Back

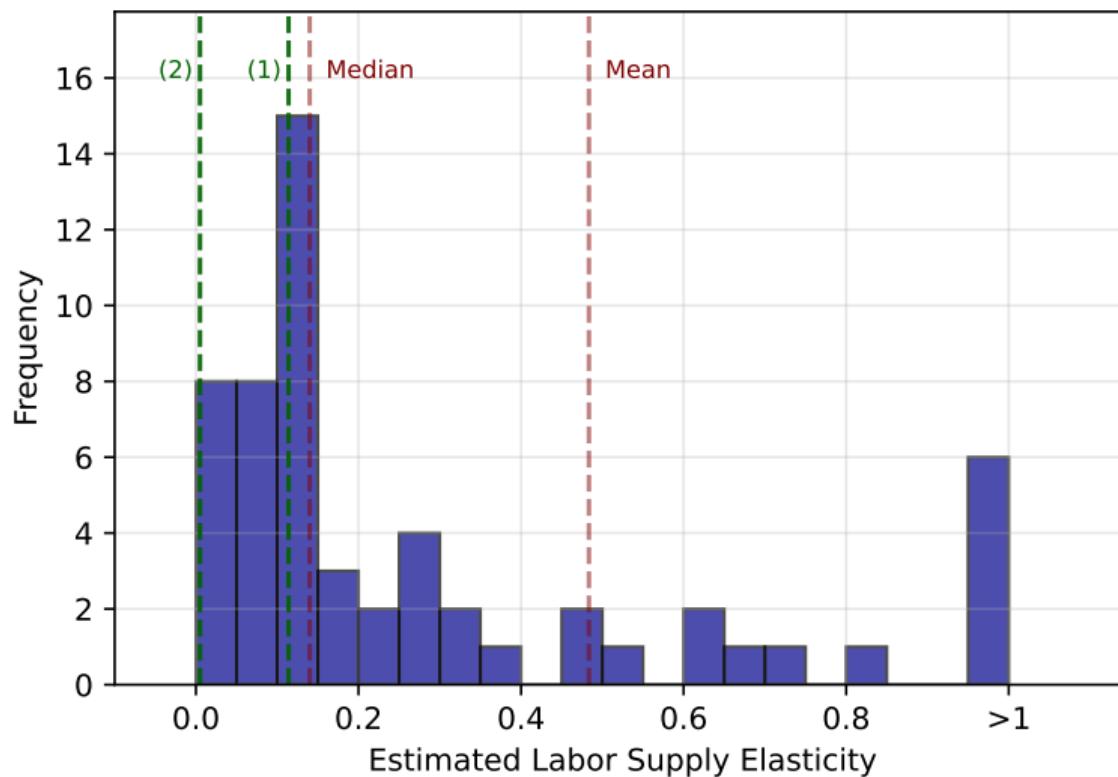
SIMULATED MINIMUM DISTANCE: OTHER MOMENTS

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

- 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 reported in Keane (2011) and Chetty (2012)

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

Reasons why elasticity may be smaller:

- ① Different **sample**: college graduates with 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)
Std. 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)
Std. 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)
Std. 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 Fixed No	0 Fixed No	0 Fixed No	0 Fixed No	0.24 Fixed No	0 Linear No	0 Fixed Yes
Adjustment cost function								
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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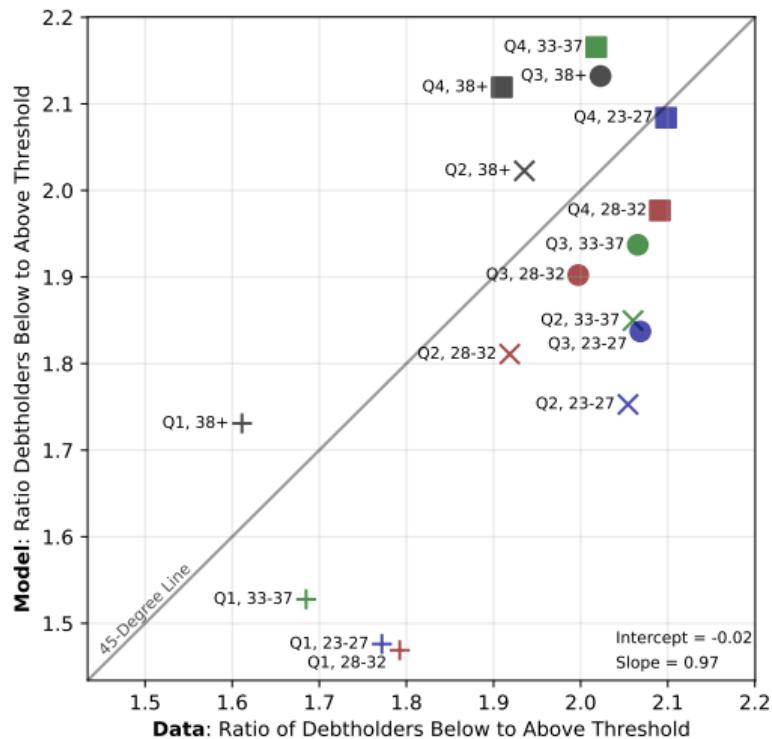
ADDITIONAL MODEL RESULTS: POSITIVE

- ① **Robustness:** $\hat{\phi} = 0.111$ with linear adjustment costs (vs. 0.114) 
- ② **Validation** of baseline model on nontargeted moments 
- ③ Bunching **decomposition**: $P(\text{Repayment}) \approx 60\%$, liquidity demands $\approx 40\%$ 
- ④ **Learning-by-doing**: cannot match heterogeneity in bunching by debt and age 

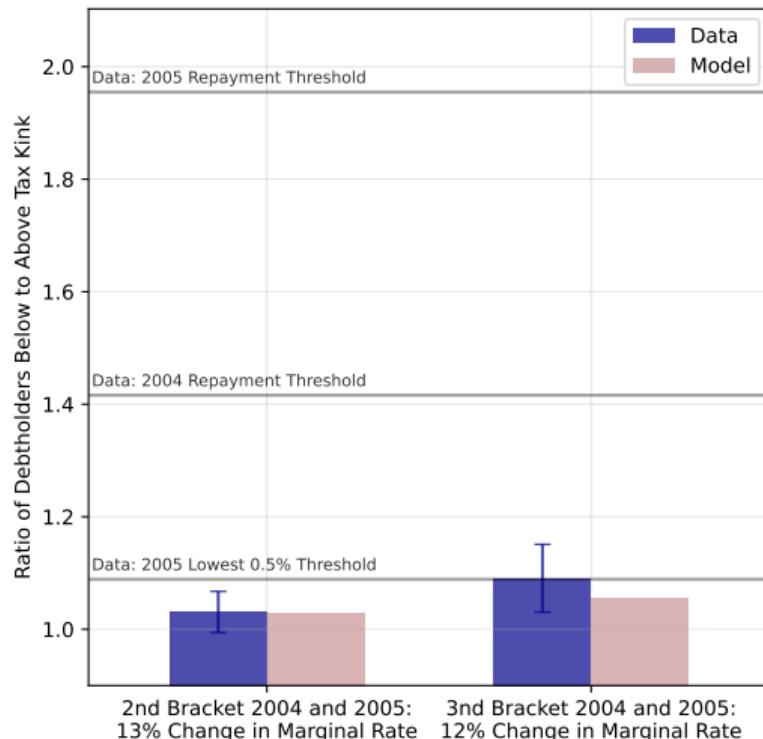
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VALIDATION OF BASELINE MODEL ON NONTARGETED BUNCHING

Heterogeneity by Debt and Age



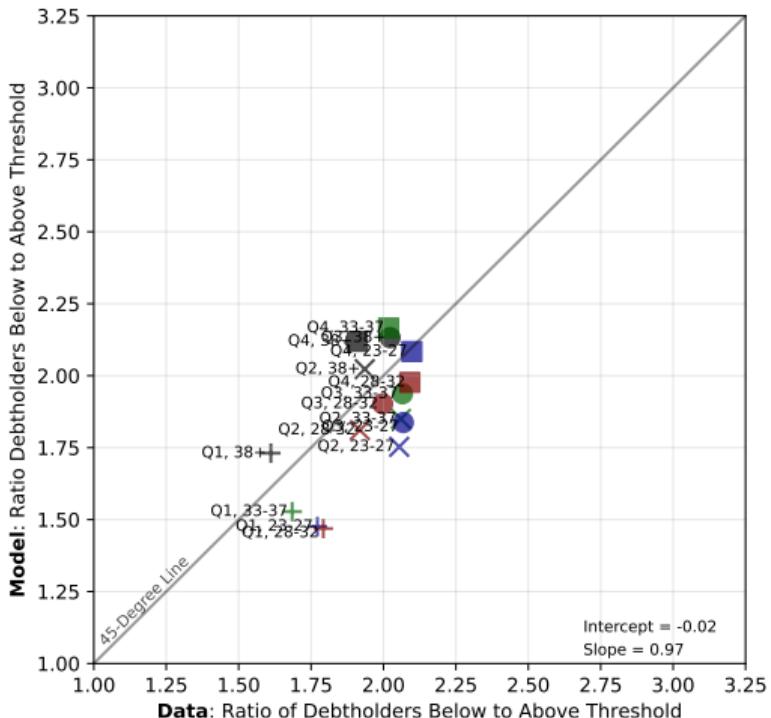
Bunching at Changes in Tax Rates



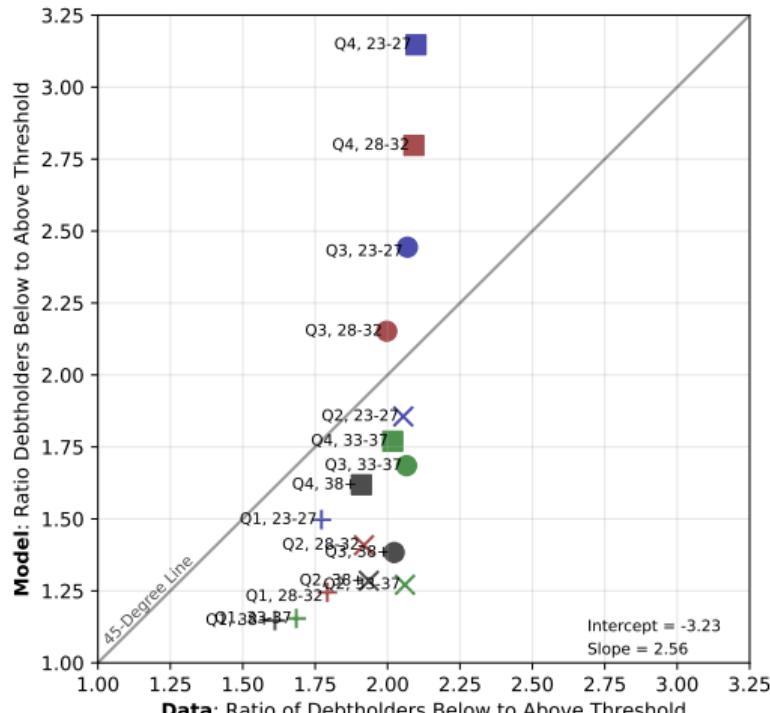
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LEARNING-BY-DOING MODEL FITS WORSE THAN BASELINE MODEL

Baseline Model

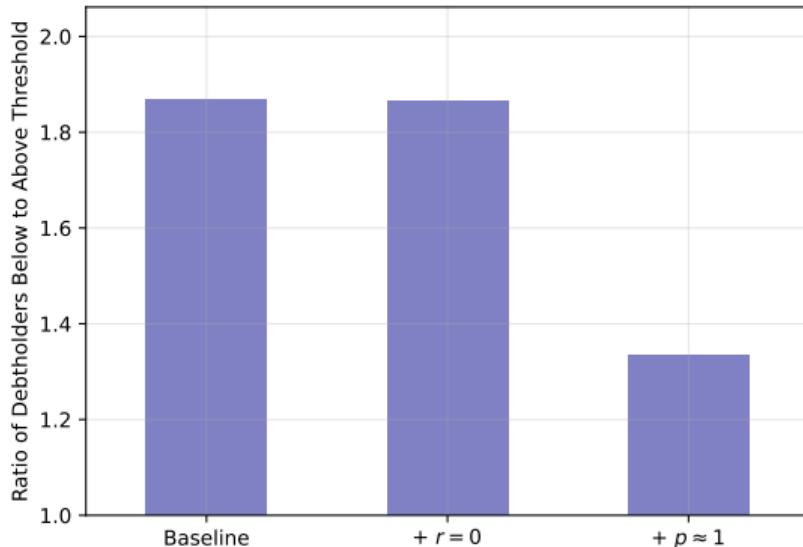
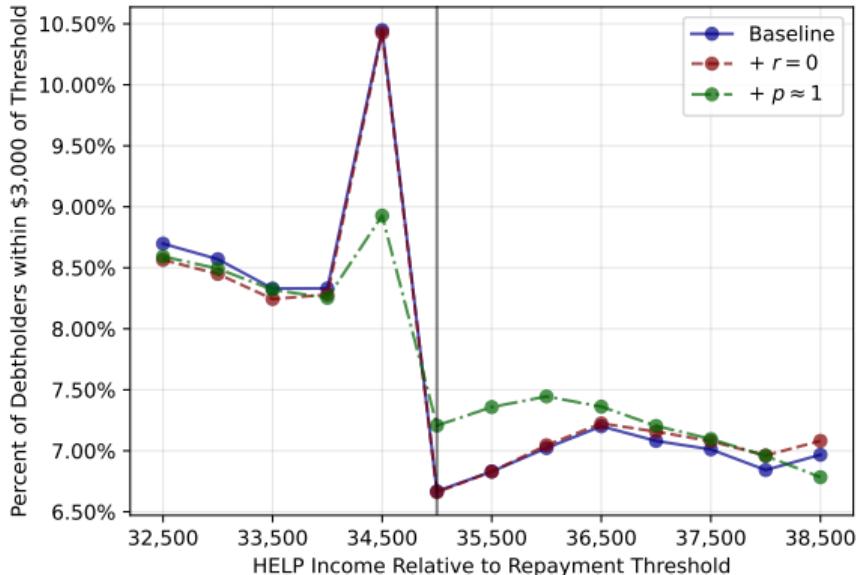


Learning-by-Doing Model



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DECOMPOSITION: RATE DIFFERENTIAL, REPAYMENT, AND LIQUIDITY

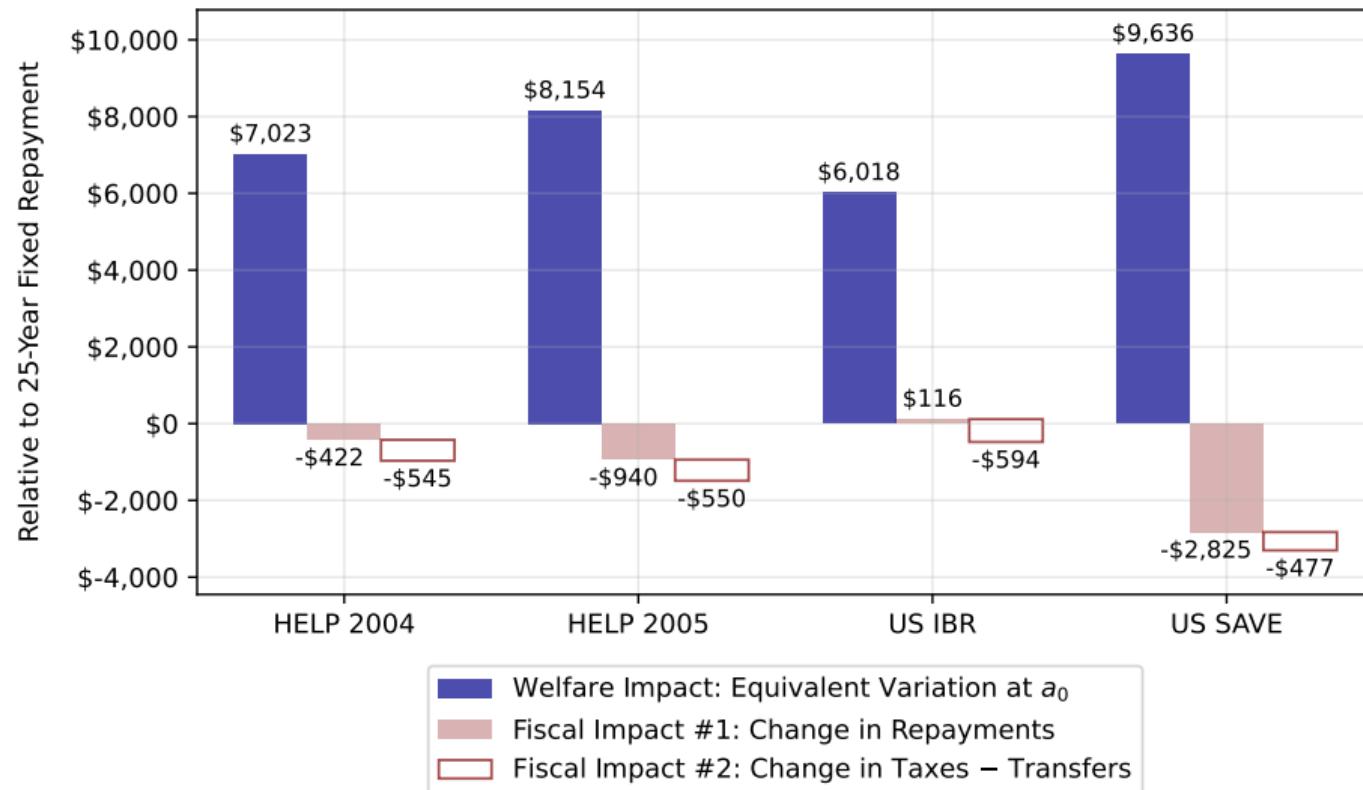


$$\text{Bunching Liquidity Gain} = \$1400 \geq \$1400 \times \frac{r + 1 - p}{1 + r} = \text{Bunching NPV Gain}$$

- Interest rate differential = $r \Rightarrow 0\%$ of bunching
- Probability of repayment = $p \Rightarrow 61\%$ of bunching
- Demand for liquidity $\Rightarrow 39\%$ of bunching (Chetty 2008, Ganong-Noel 2023, Indarte 2023)

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EXISTING INCOME-CONTINGENT LOANS VS. FIXED REPAYMENT

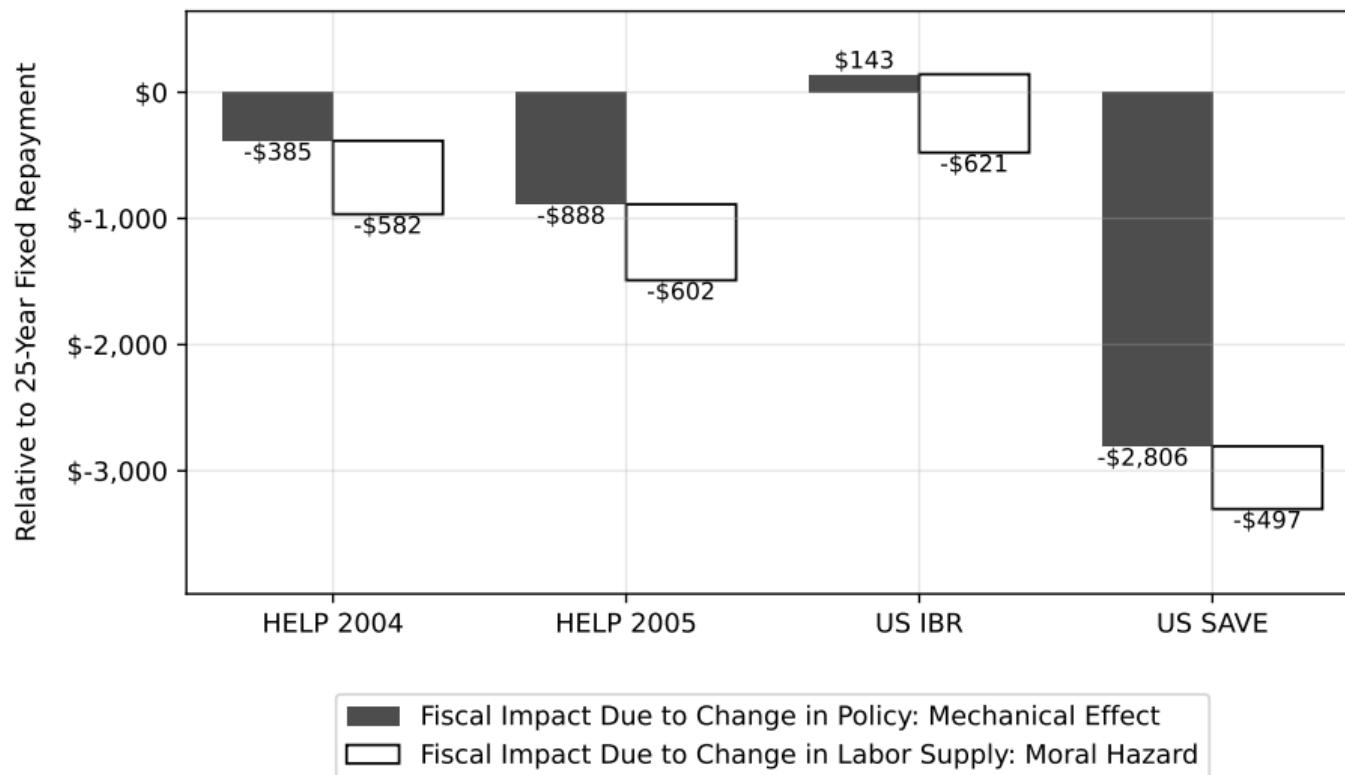


► Decomposition

► MVPF

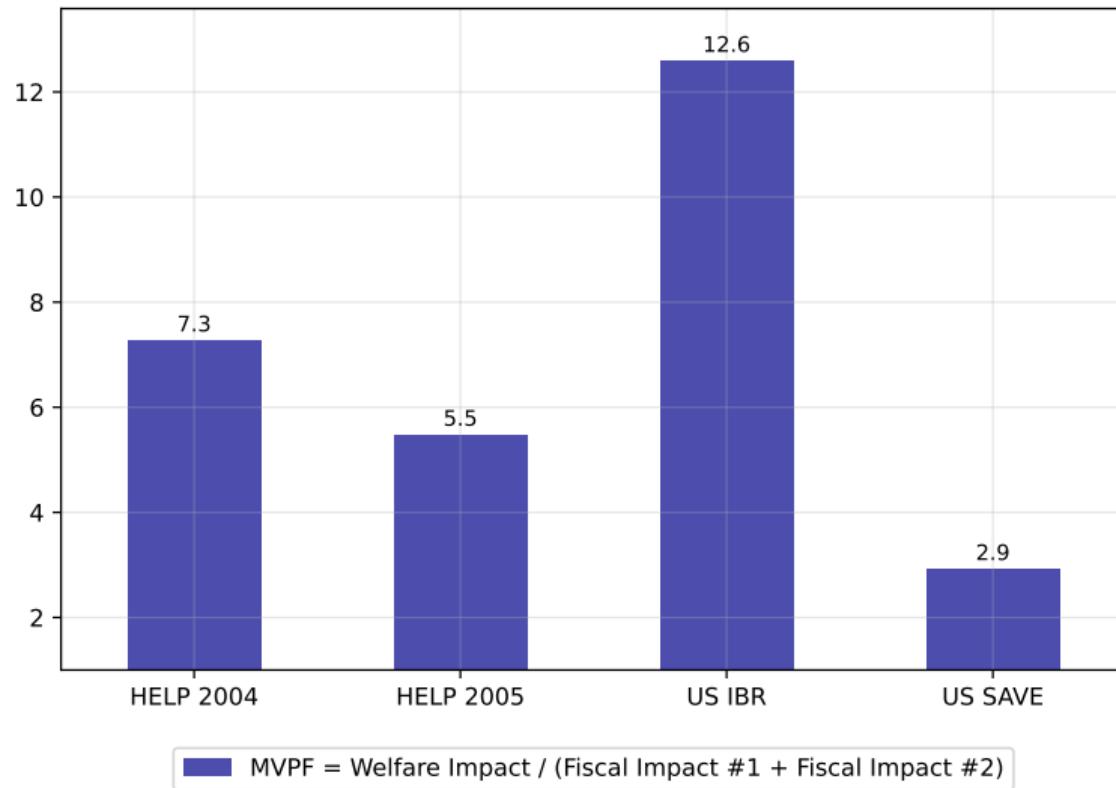
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DECOMPOSITION OF FISCAL IMPACT: ENDOGENOUS LABOR SUPPLY



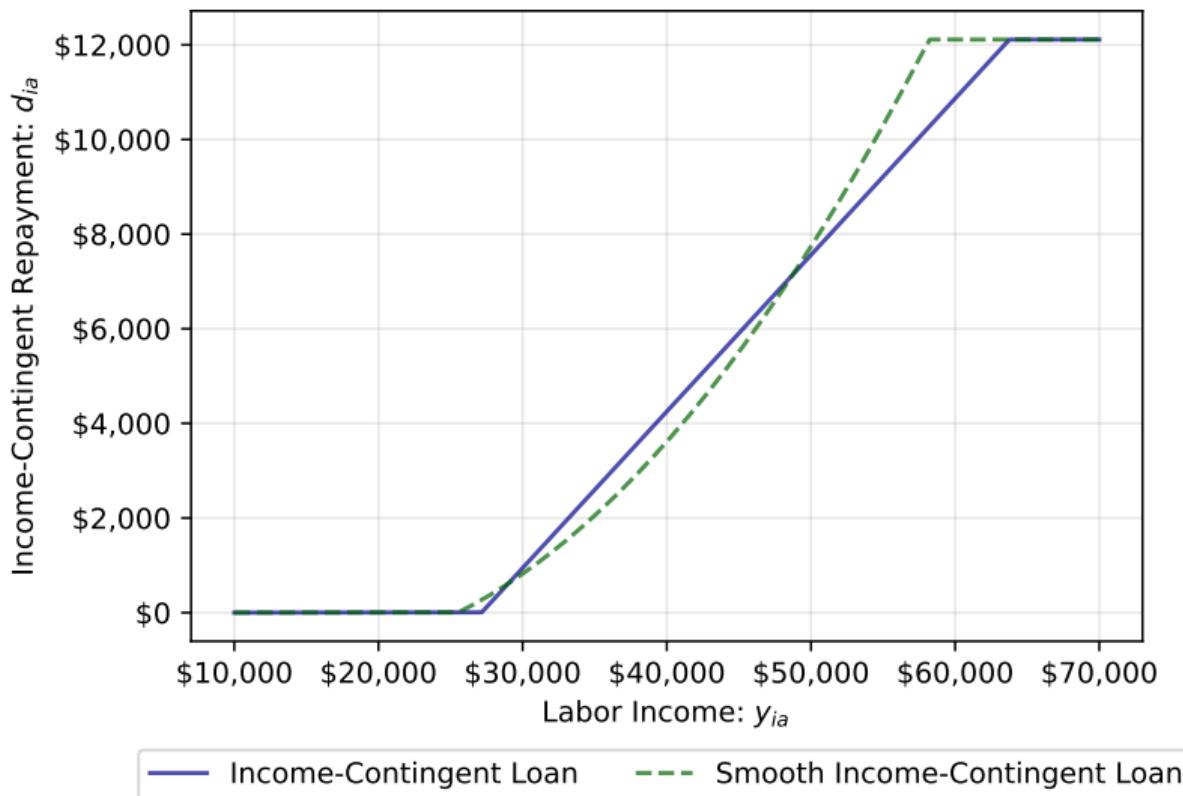
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MARGINAL VALUE OF PUBLIC FUNDS



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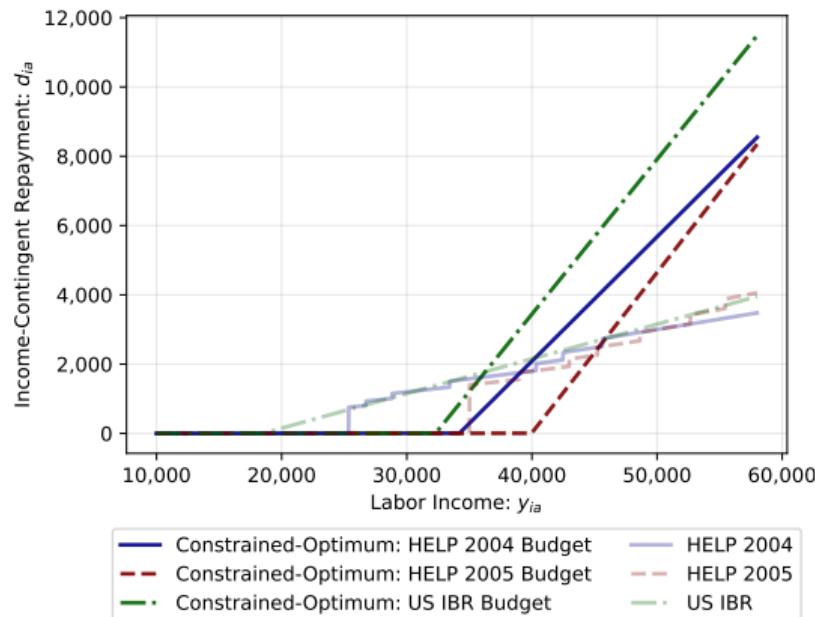
SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM: QUADRATIC



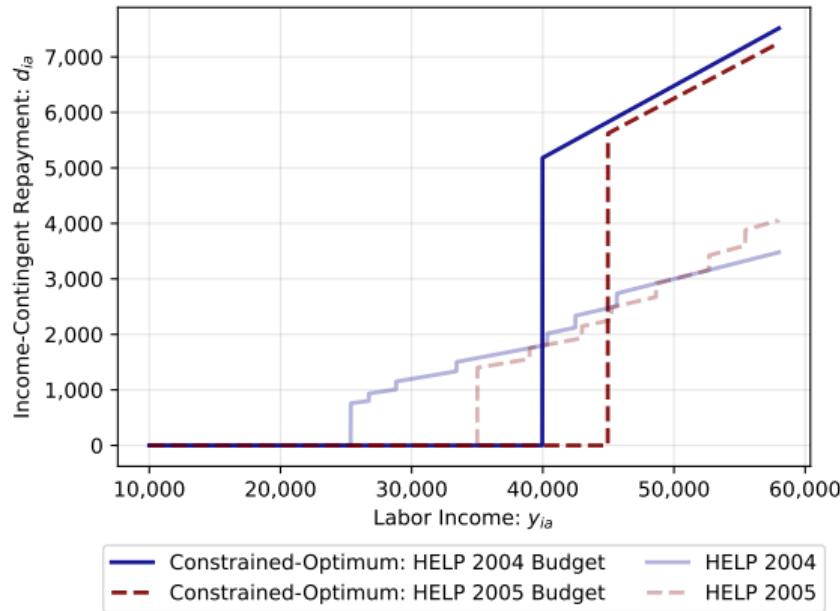
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OPTIMAL VERSUS EXISTING INCOME-CONTINGENT LOANS

Change in Marginal Rate

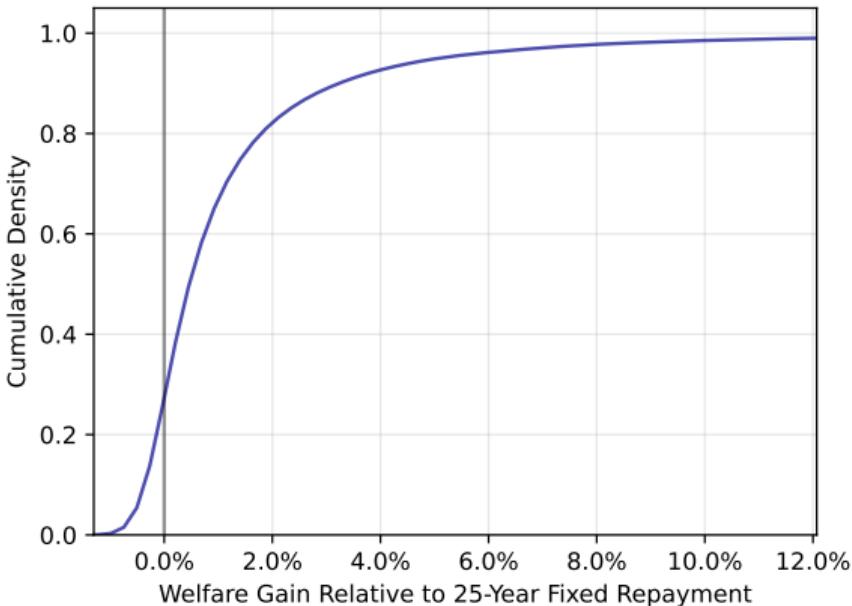
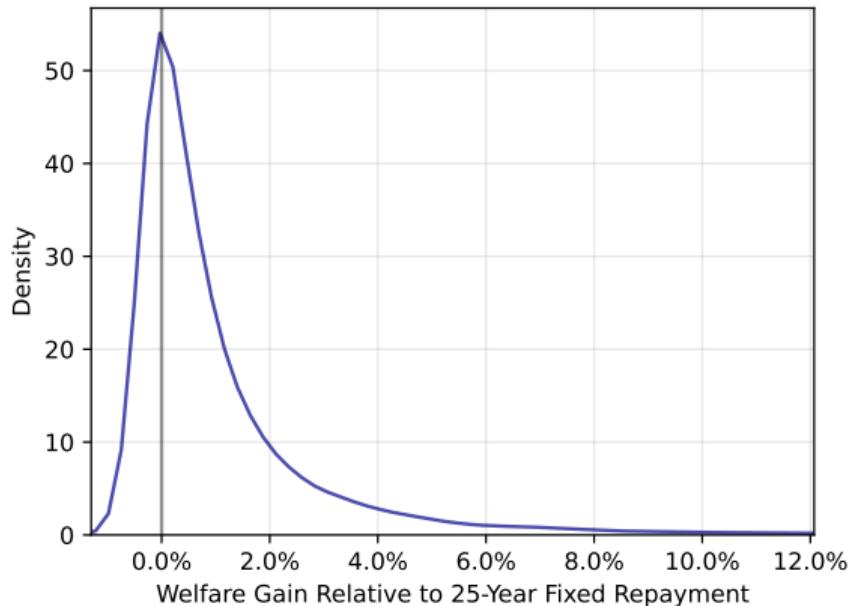


Change in Average Rate



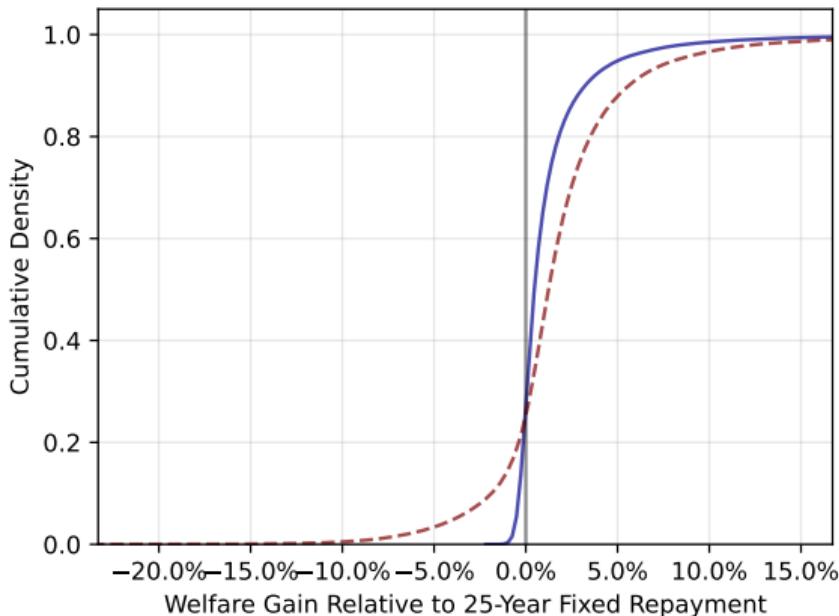
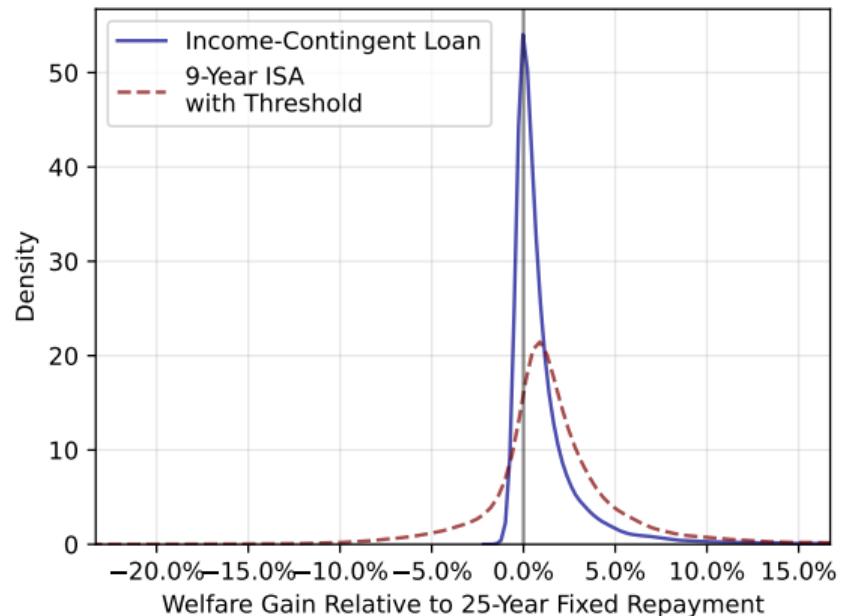
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DISTRIBUTION OF INITIAL WELFARE GAINS: ICL



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

DISTRIBUTION OF INITIAL WELFARE GAINS: ICL vs. EQUITY

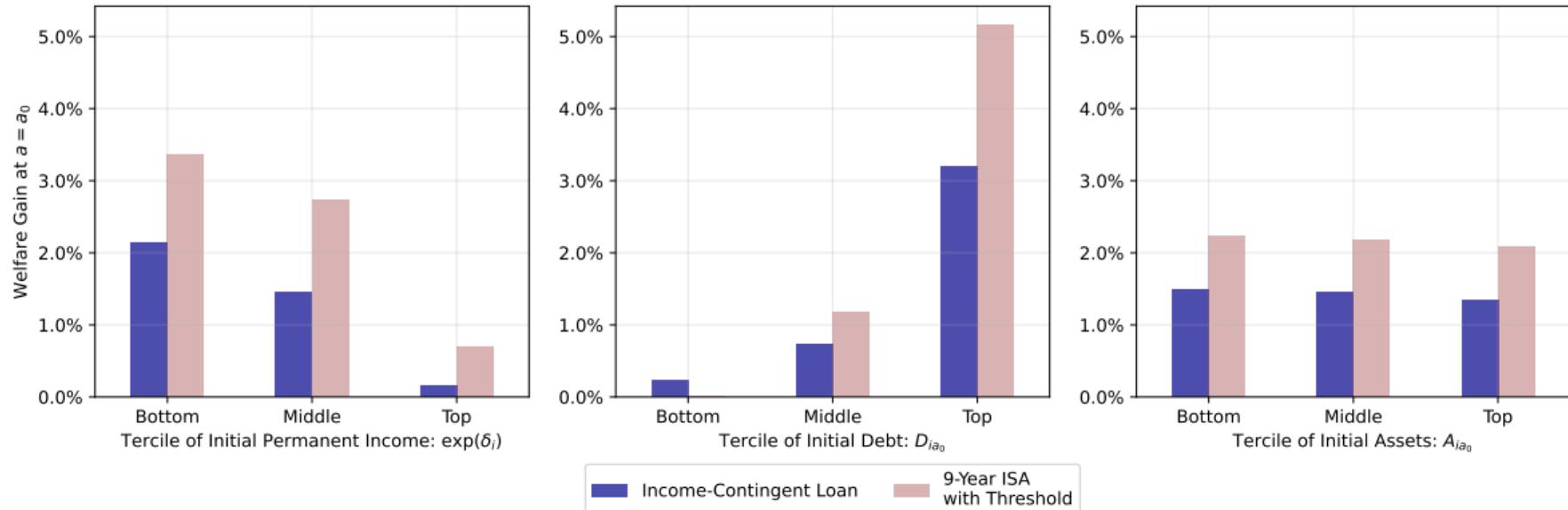


- **18%** of borrowers have welfare loss above 0.5% for equity vs. **1.2%** for ICL

▶ Heterogeneity by Initial States

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HETEROGENEITY IN WELFARE GAINS ACROSS INITIAL STATES



▶ Losers under ICL

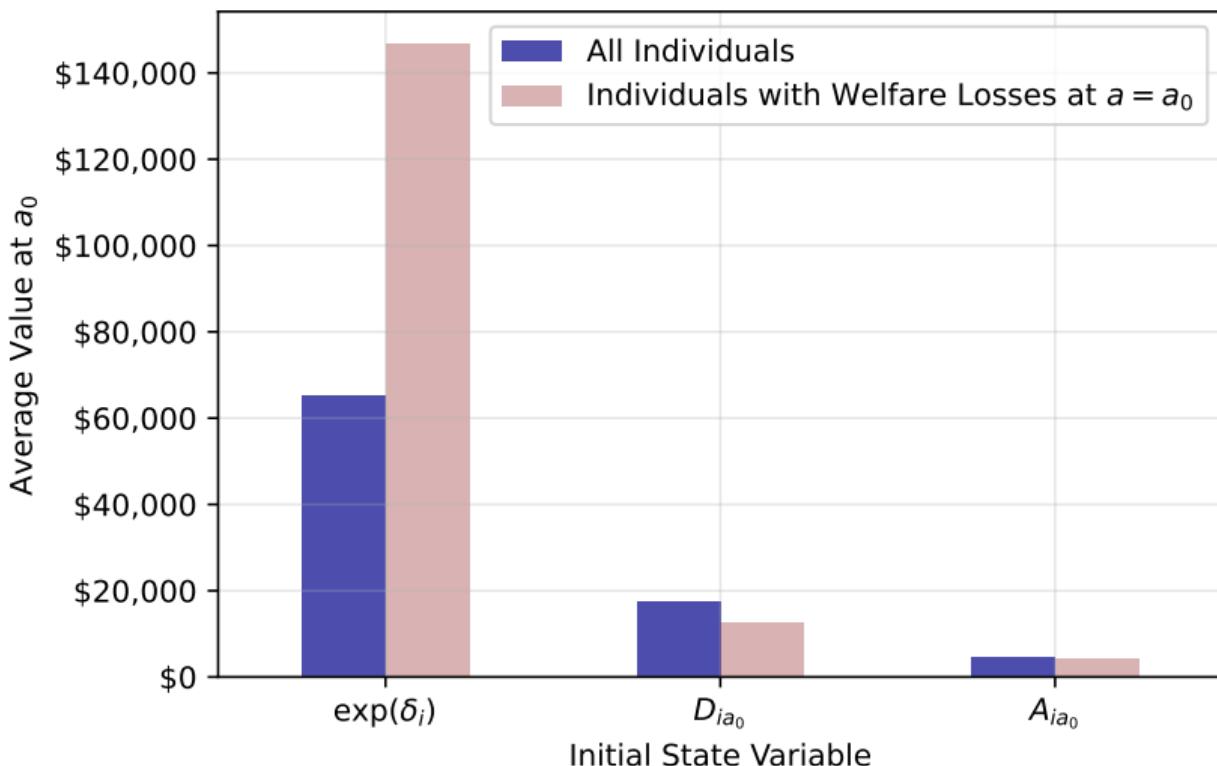
▶ Heterogeneity by Age

▶ Heterogeneity by Initial Debt

◀ Back: ICL Gain

◀ Back: Contracts

INDIVIDUALS WITH INITIAL WELFARE LOSSES: ICL



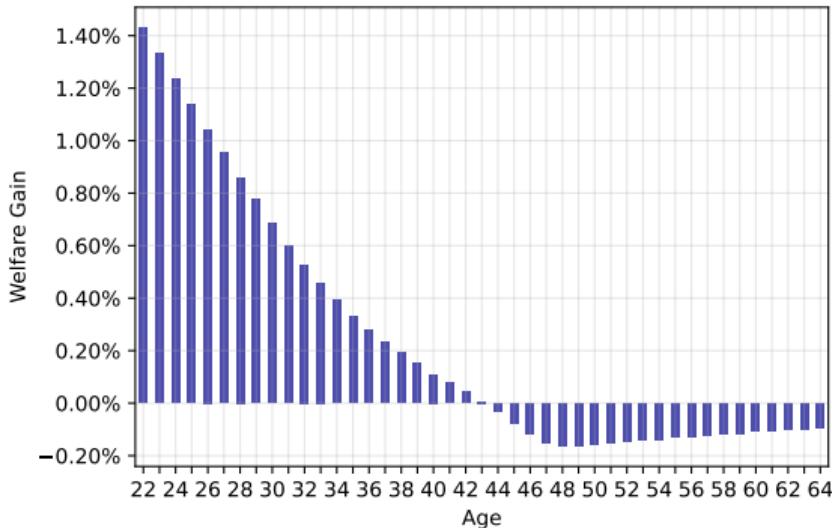
► Heterogeneity by Age

◀ Back: ICL Gain

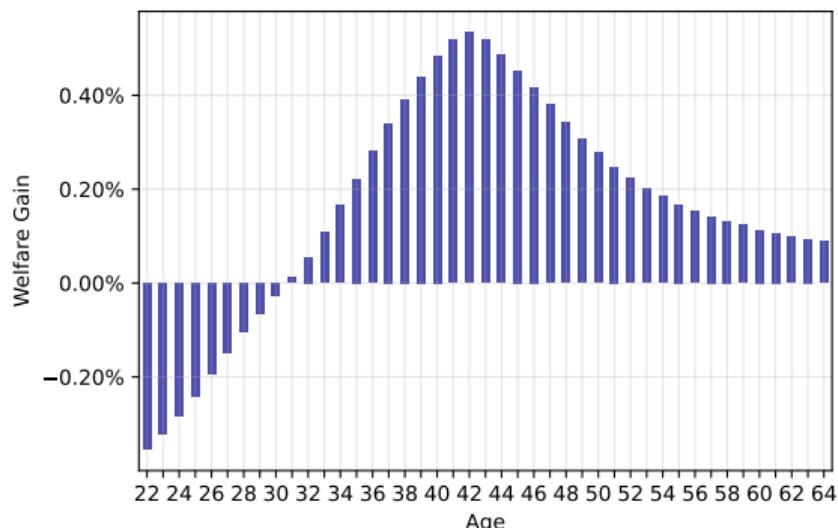
◀ Back: Contracts

WELFARE GAINS BY AGE

ICL vs. 25-Year Fixed



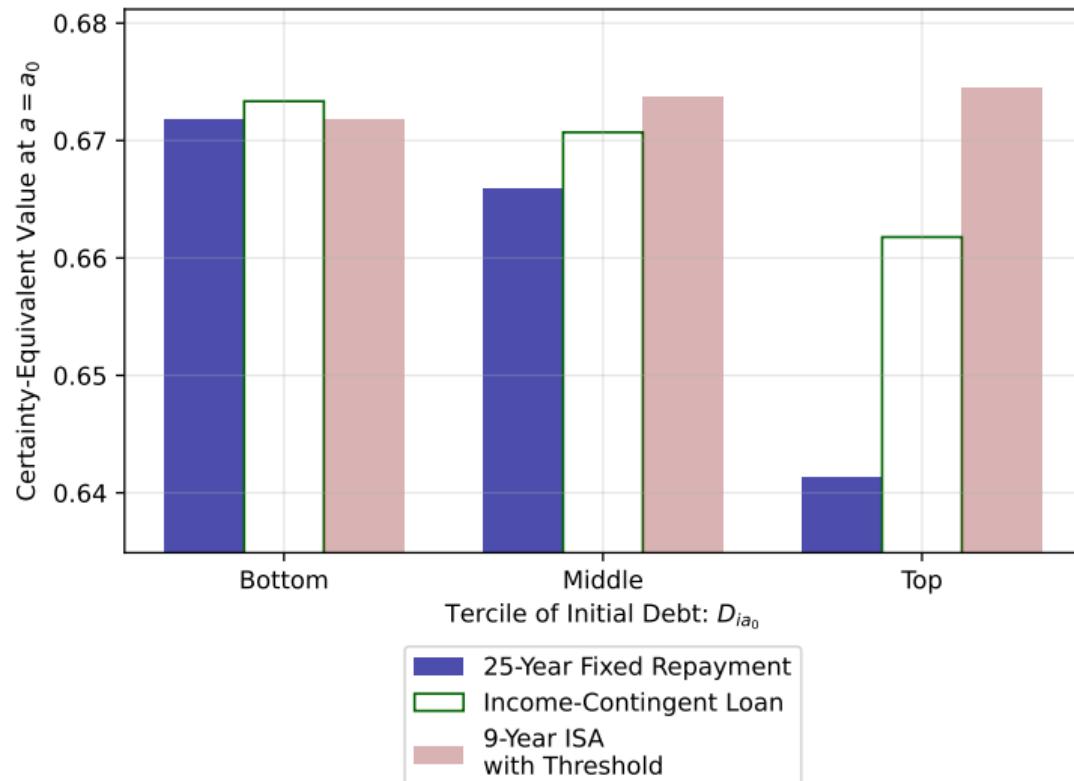
ICL + 20-Year Forgiveness vs. ICL



◀ Back: ICL Gain

◀ Back: Contracts

CERTAINTY-EQUIVALENTS ACROSS INITIAL DEBT

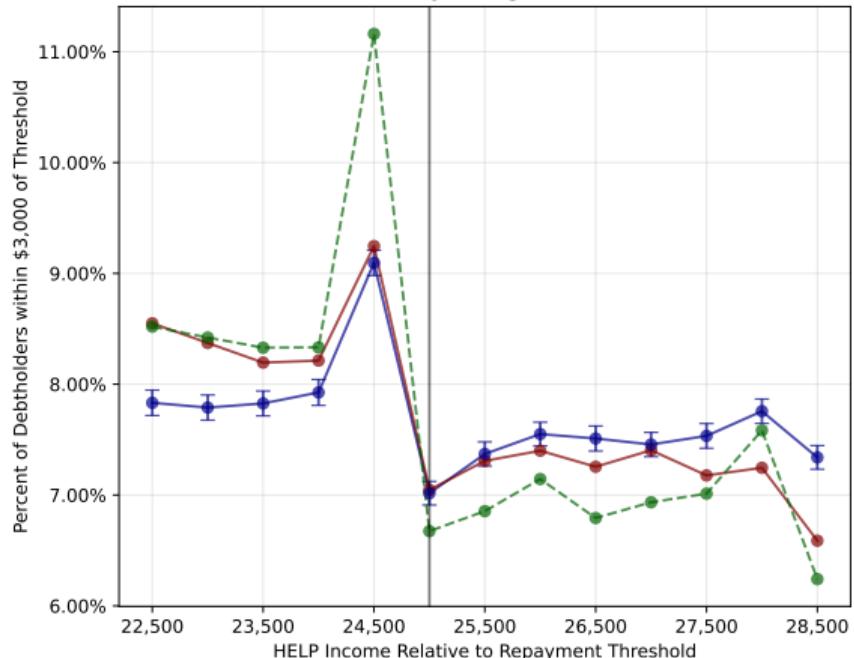


◀ Back: ICL Gain

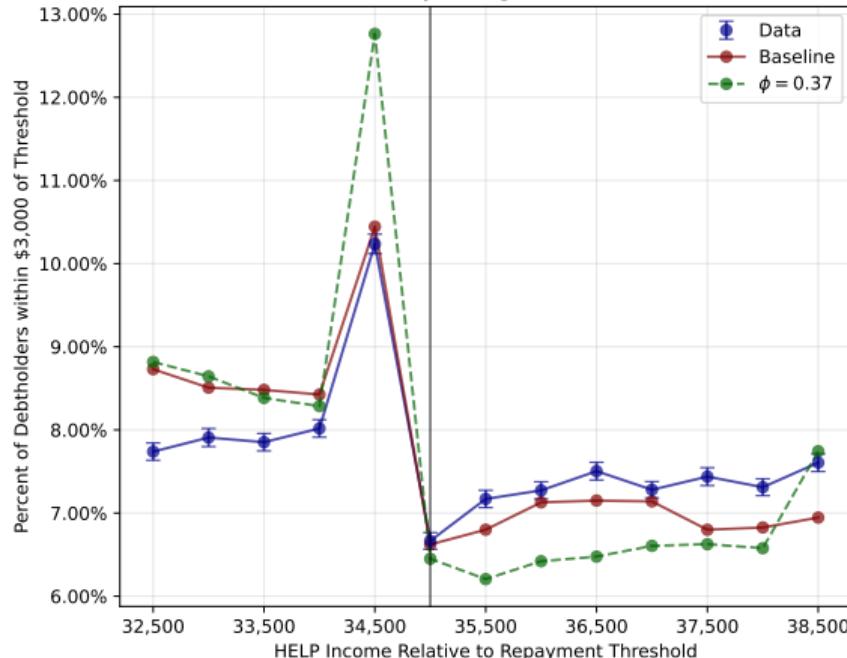
◀ Back: Contracts

FIT OF MODEL IN WHICH FIXED REPAYMENT IS OPTIMAL

Before Policy Change: 2002-2004



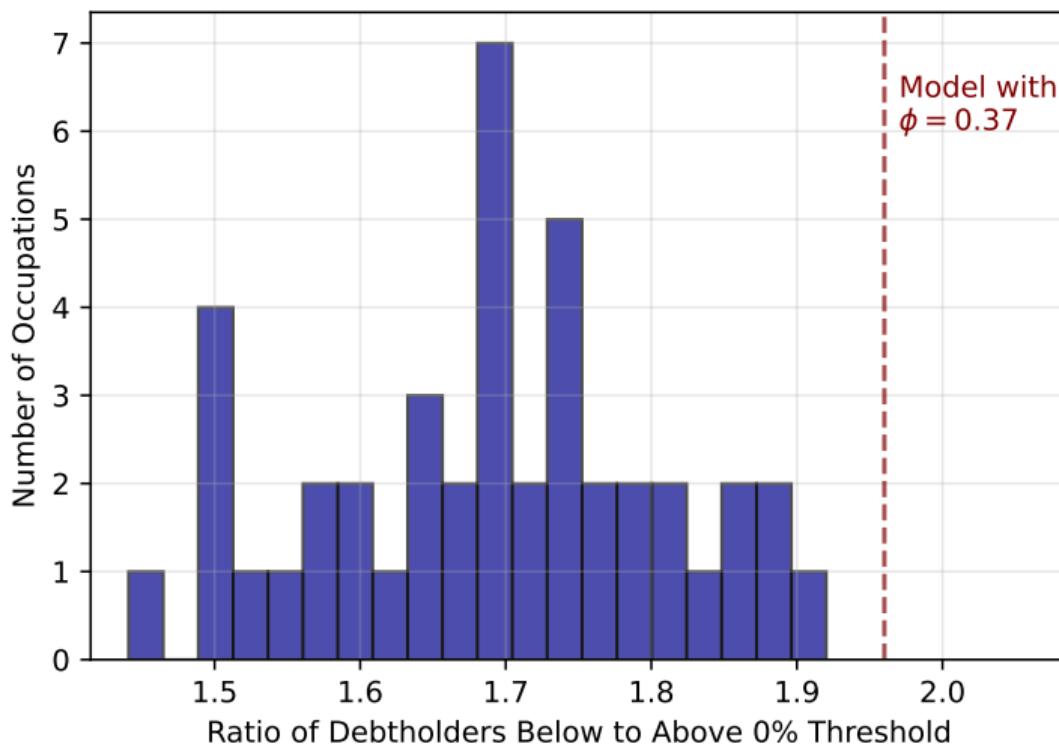
After Policy Change: 2005-2007



▶ Occupations

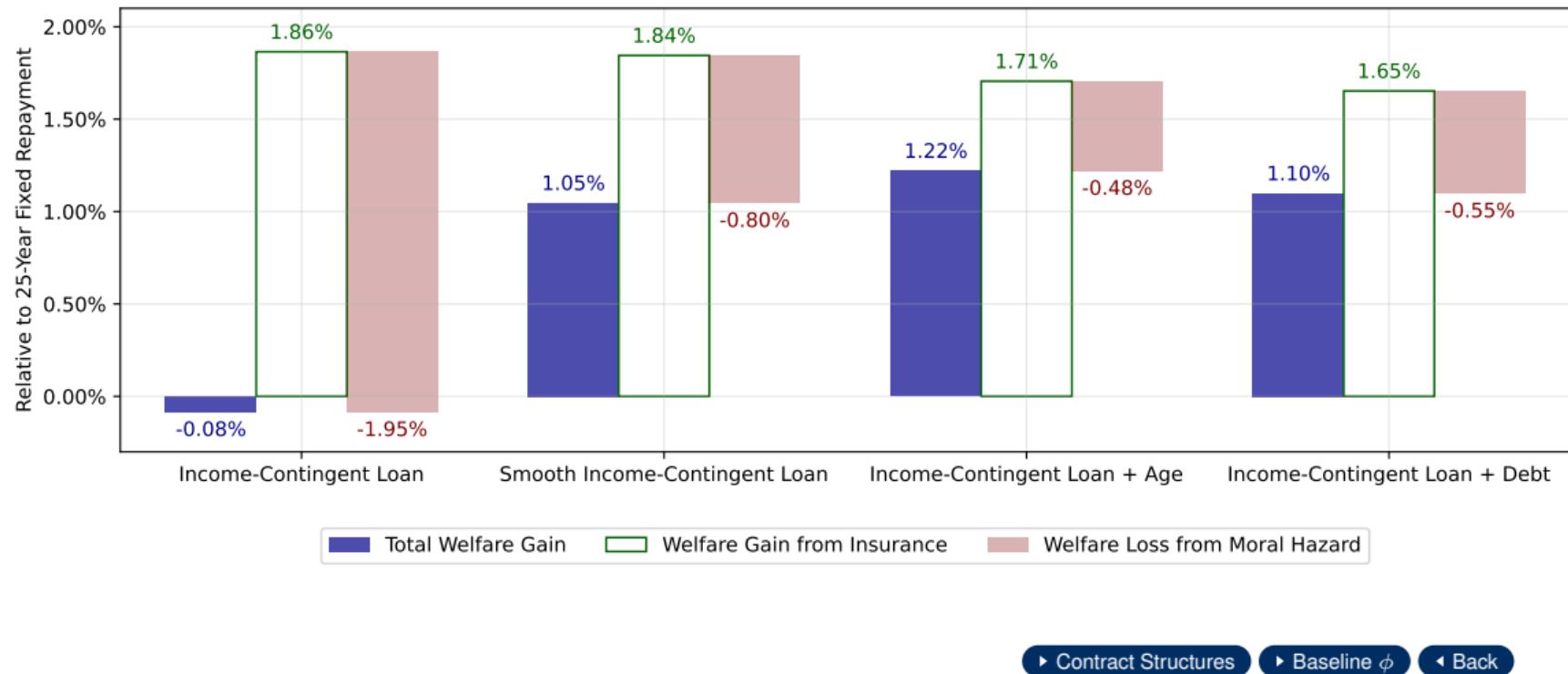
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BUNCHING WHEN FIXED REPAYMENT IS OPTIMAL vs. OCCUPATIONS

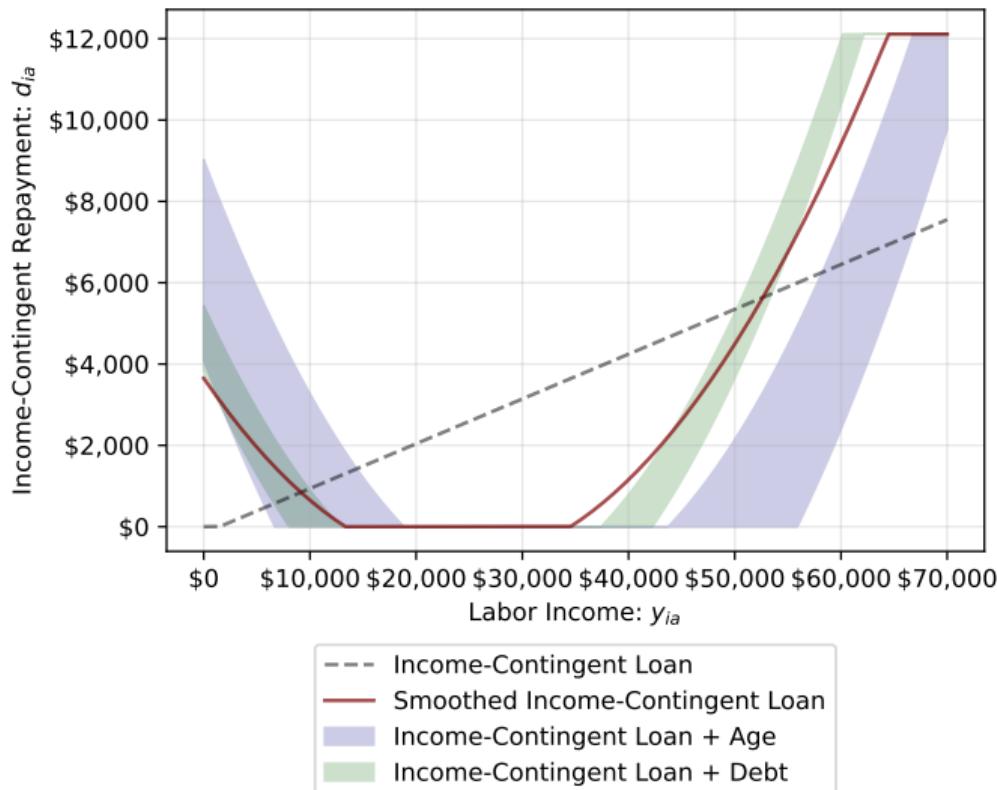


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ALTERNATIVE CONTRACTS REDUCE WELFARE COST OF MORAL HAZARD

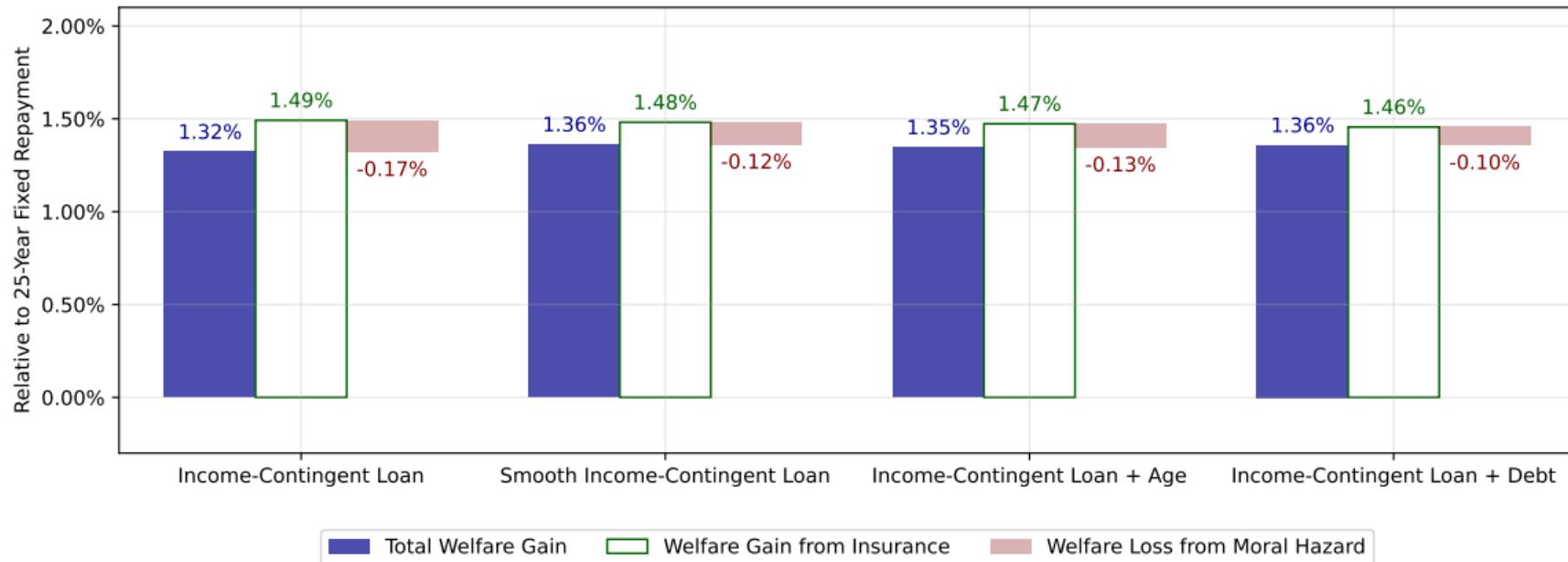


ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: $\phi = 0.37$



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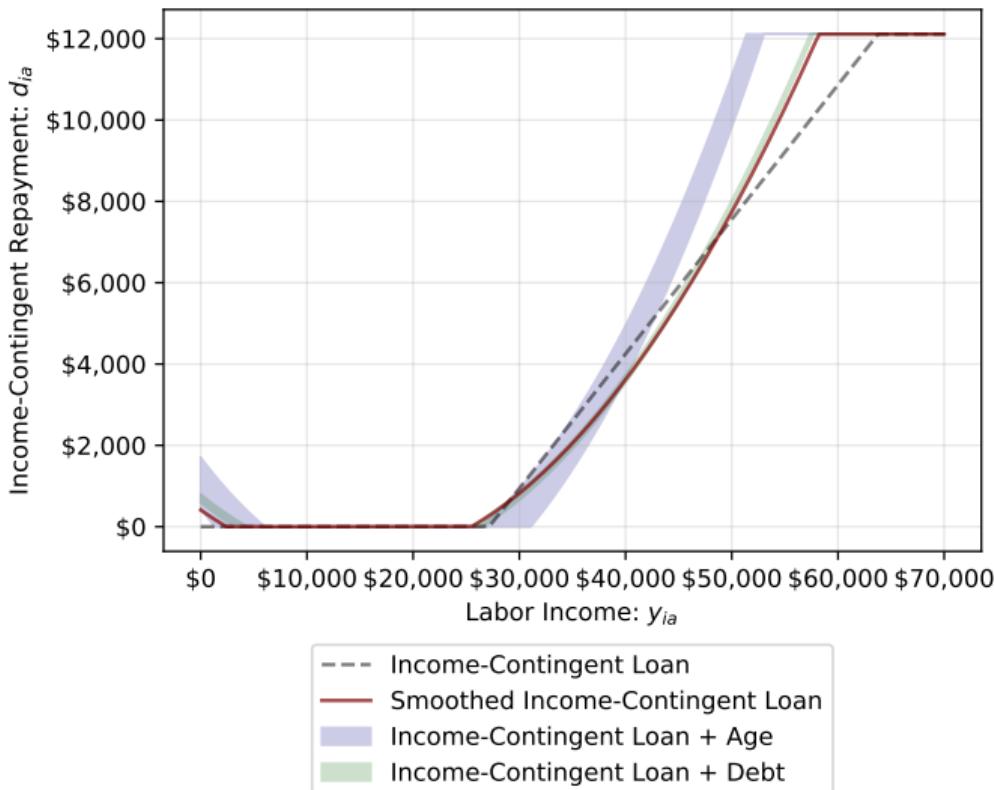
REDUCING WELFARE COST OF MORAL HAZARD: BASELINE ϕ



▶ Contract Structures

◀ Back

ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: BASELINE ϕ



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ROBUSTNESS TO MODEL MISSPECIFICATION

	Difference from Baseline	Welfare Gain	= Insurance	+ Moral Hazard	ψ^*	K^*
(1)	Fixed Cost Only	1.00%	1.49%	-0.49%	21%	\$22,711
(2)	Calvo Only	2.02%	2.10%	-0.08%	64%	\$46,452
(3)	Linear Adjustment Cost	1.74%	1.87%	-0.13%	53%	\$43,560
(4)	Occupation Heterogeneity	1.32%	1.45%	-0.13%	41%	\$28,694
(5)	Learning-by-Doing	1.68%	.	.	35%	\$36,615
(6)	Wealth Effects	0.82%	1.05%	-0.23%	37%	\$30,307
(7)	Less Persistence: $\rho = 0.8$	0.90%	1.14%	-0.23%	42%	\$34,244
(8)	More Persistence: $\rho = 0.99$	1.35%	1.63%	-0.28%	35%	\$18,949
(9)	Non-Normal 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)	Discount Rate = R	1.06%	1.41%	-0.35%	29%	\$22,696
(12)	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)	US Initial Debt Levels	3.50%	4.72%	-1.22%	36%	\$18,867
(15)	Riskless Borrowing: $\tau_b = 0\%$	1.68%	1.82%	-0.15%	44%	\$39,809
(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%	1.64%	-0.28%	37%	\$30,939
	Baseline Model	1.32%	1.47%	-0.15%	33%	\$27,147

◀ Back: Additional Results

ROBUSTNESS TO ALTERNATIVE MODELS OF FRICTIONS

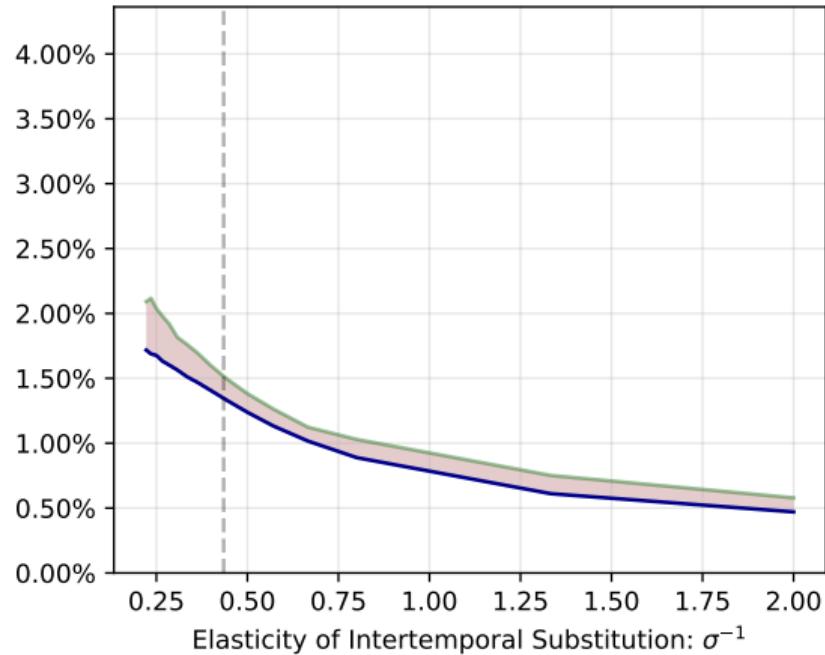
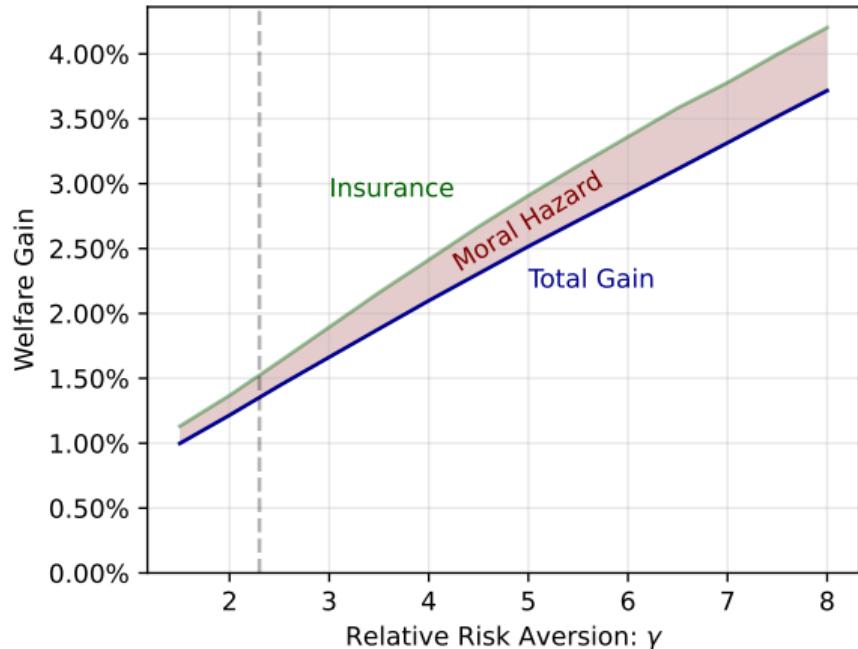
Difference from Baseline Model	Welfare Gain = Insurance	+ Moral Hazard	ψ^*	K^*
(1) $f = 0$	1.31%	1.61%	-0.3%	46% \$29,618
(2) $f = \$2278$	1.49%	1.65%	-0.16%	64% \$33,915
(3) $\lambda = 1$	1.27%	1.34%	-0.07%	38% \$28,191
(4) $\lambda = 0.147$	1.32%	1.47%	-0.15%	40% \$28,492
(5) Fixed Adjustment Cost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

◀ Back: Additional Results

EFFECTS OF CHANGING RISK AVERSION AND EIS



◀ Back: Fixed Point ϕ

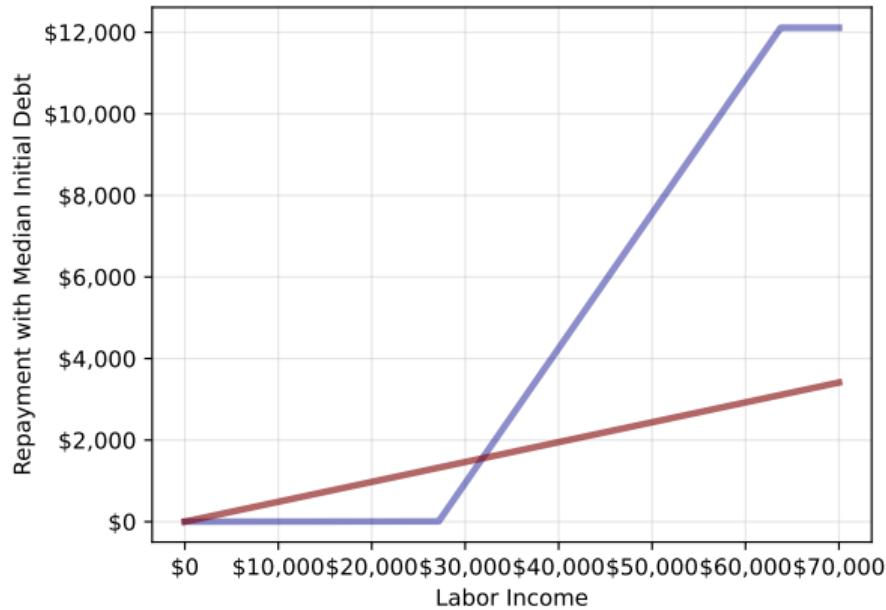
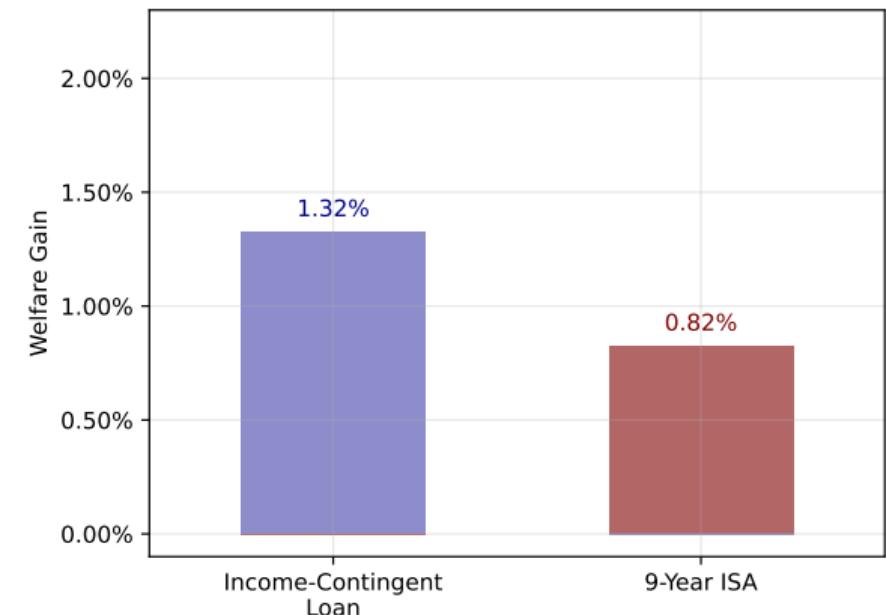
◀ Back: Additional Results

ADDITIONAL MODEL RESULTS: NORMATIVE

- ① Robustness to
 - Different sources of **model mispecification** 
 - Different adjustment **frictions** 
 - Different values of **RRA** and **EIS** 
- ② **Pure equity** contract does worse than income-contingent loan 
- ③ With **optimal tax** progressivity, forbearance is enough and gains are smaller 

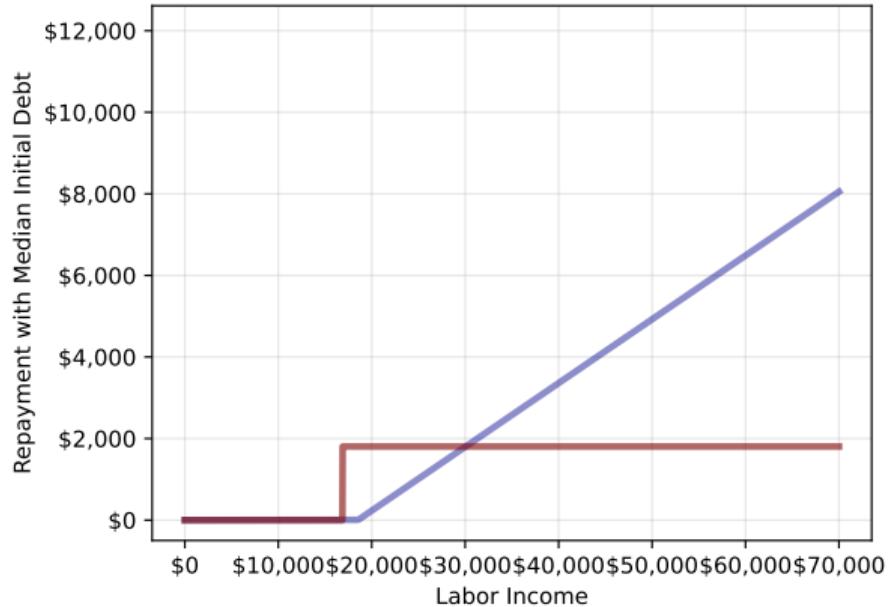
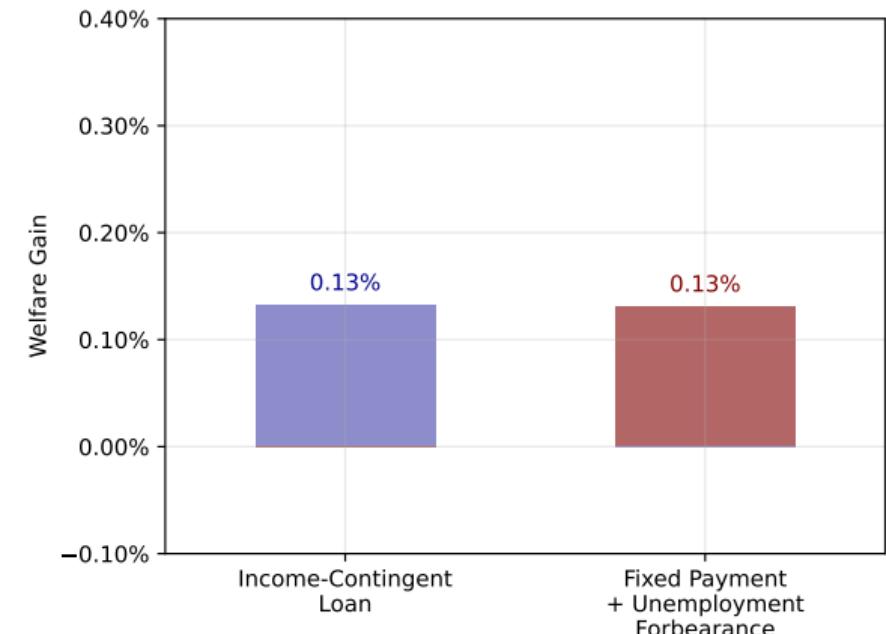
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PURE EQUITY DOES WORSE THAN INCOME-CONTINGENT LOAN



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WELFARE GAINS WITH OPTIMAL TAX PROGRESSIVITY



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SHORTCUTS IN ADOBE ACROBAT

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- Mac: Cmd + Shift + N