

# INSURANCE VERSUS MORAL HAZARD IN INCOME-CONTINGENT STUDENT LOAN REPAYMENT

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MIT Sloan

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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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  - Student loans = \$1.6 trillion in US and 10% of household debt in US and UK

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- + Encourage risk-taking
- Incentivize over-borrowing

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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

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

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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
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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 Theories of human capital financing Lochner-Monge-Naranjo 2016, Stantcheva 2017
- ② Empirical effects of student loans
  - ↑ Debt ⇒ ↑ delinquencies, ↓ mobility, ↓ income Di Maggio et al. 2021, ↓ homeownership Mezza et al. 2020, Δ occupation Luo-Mongey 2019, Δ major Hampole 2022
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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
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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

- 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

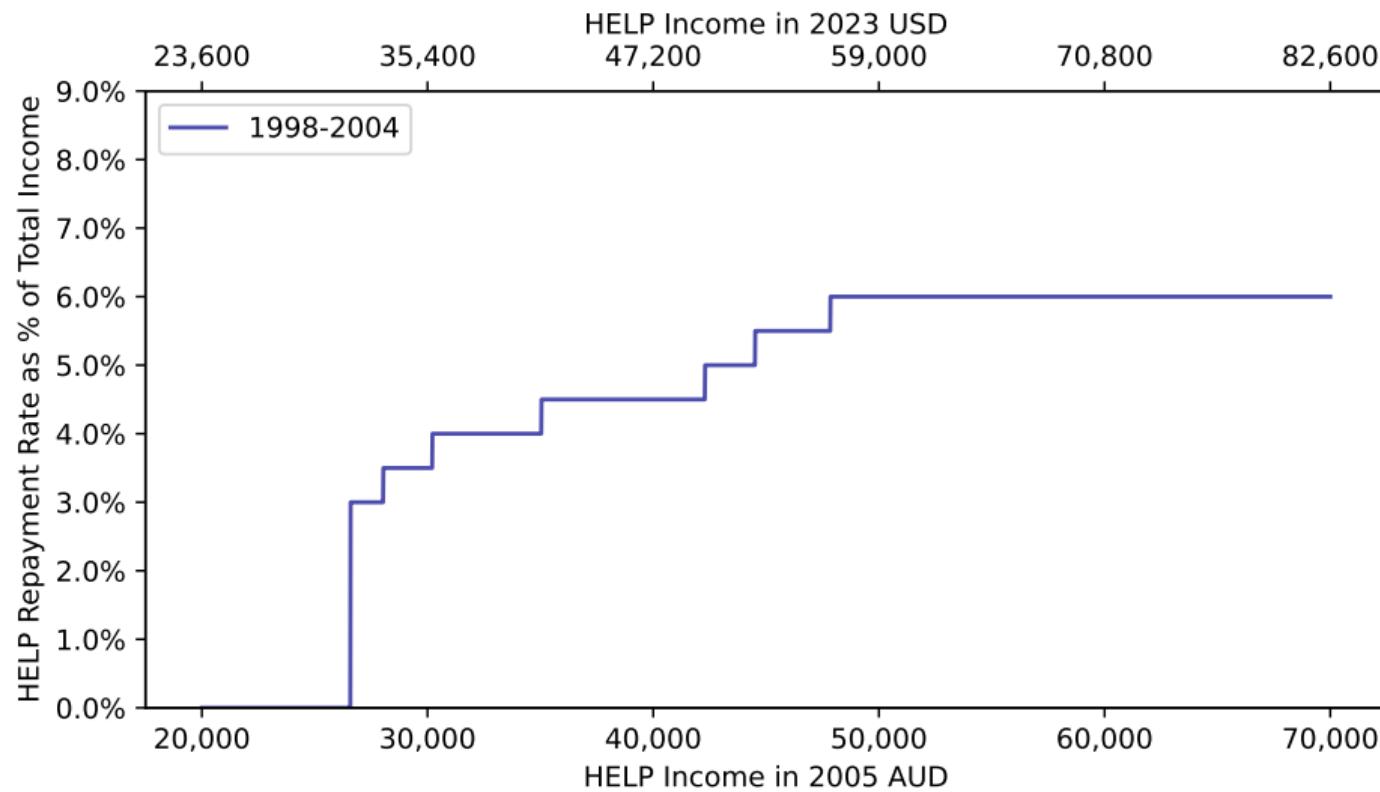
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**Sample:** ~ 4 million **unique** debtholders between ages 20-64 from 1991-2018

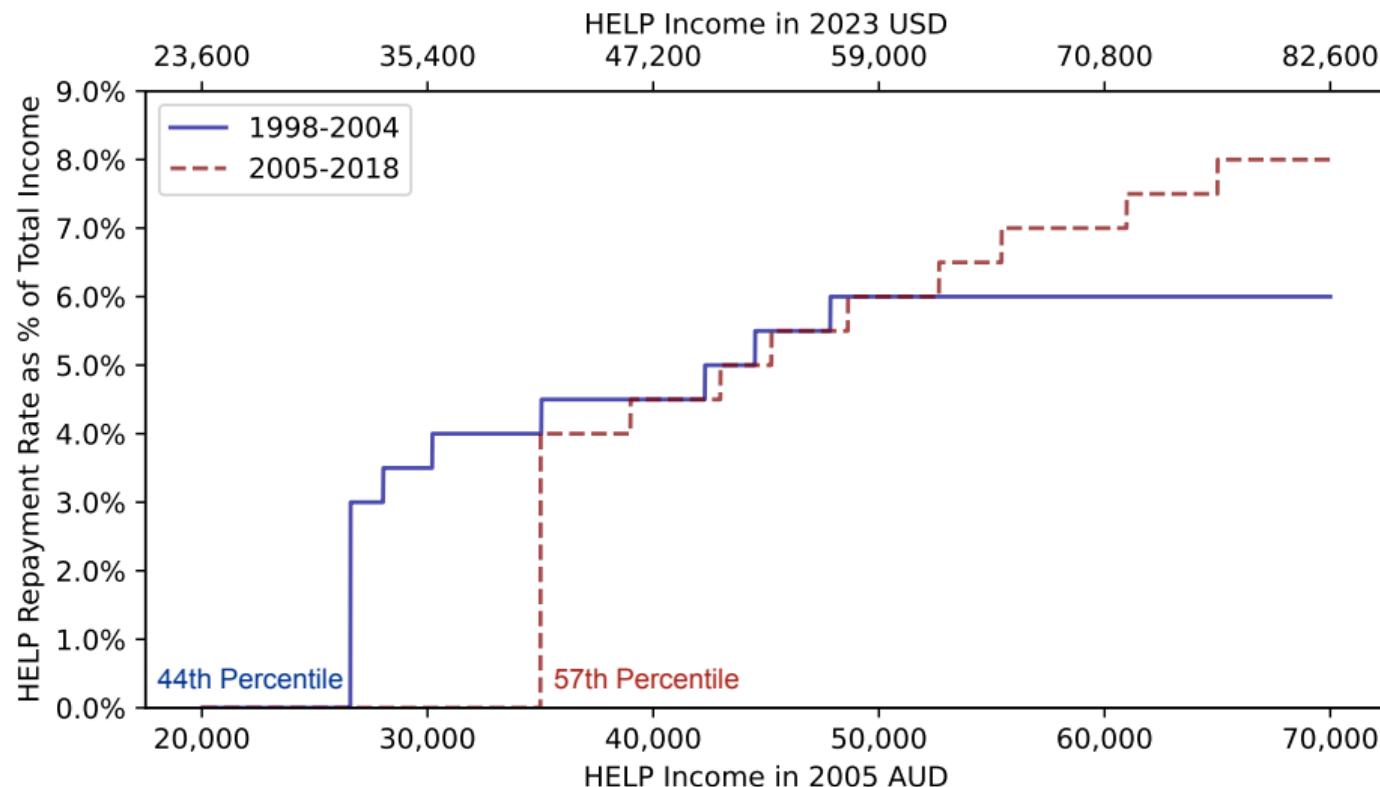
- Mean HELP Income at age 26 = \$34K with 98% from labor income

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

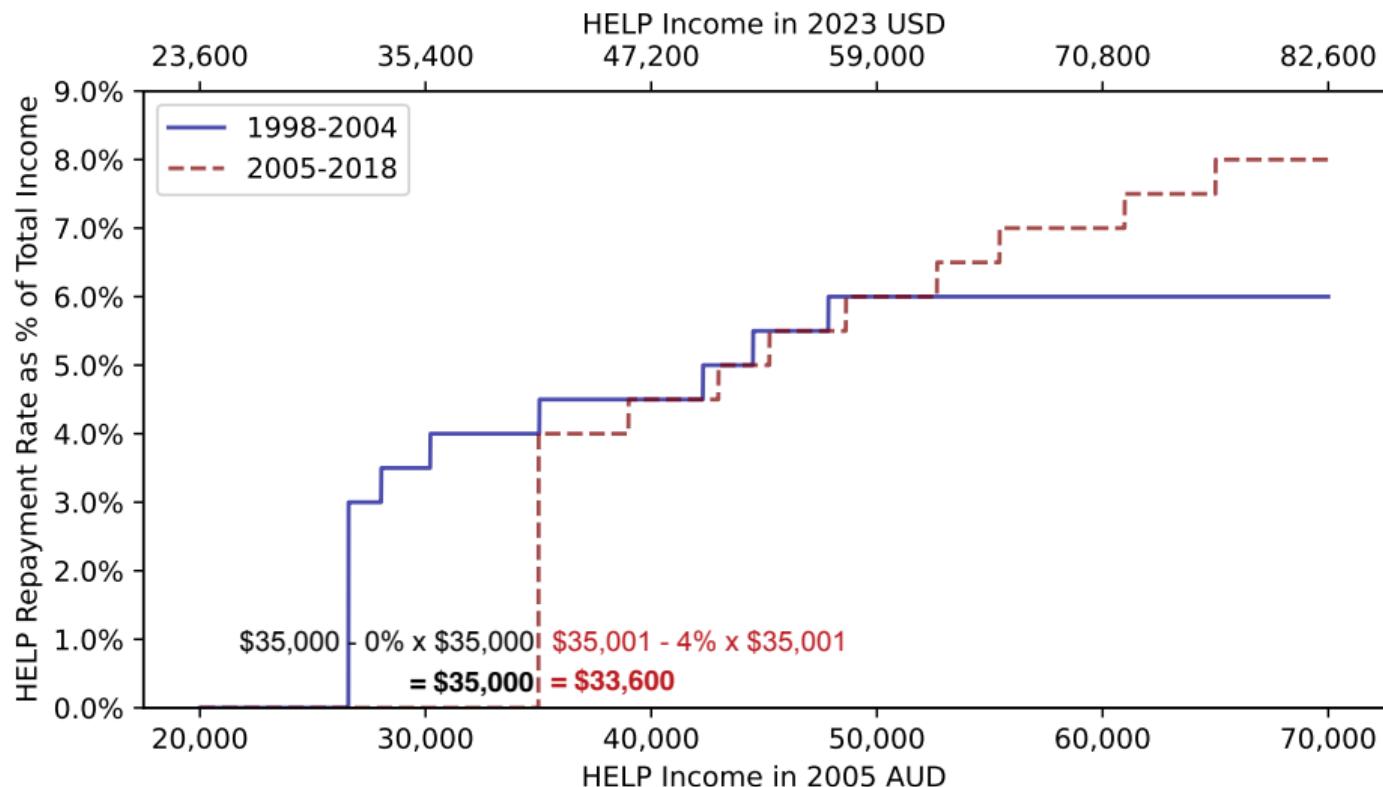
# IDENTIFYING VARIATION: DISCONTINUITIES IN REPAYMENT RATES



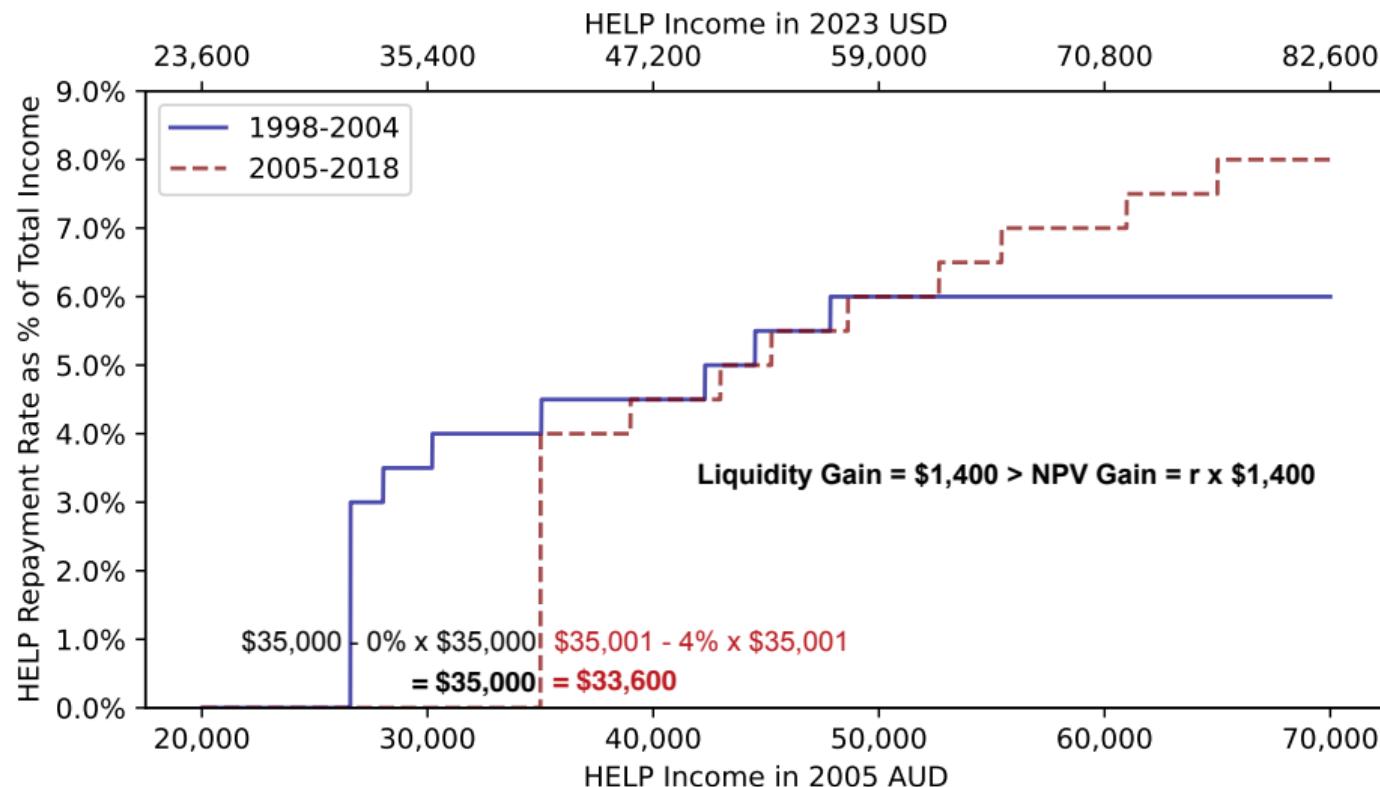
# IDENTIFYING VARIATION: POLICY CHANGE TO REPAYMENT RATES



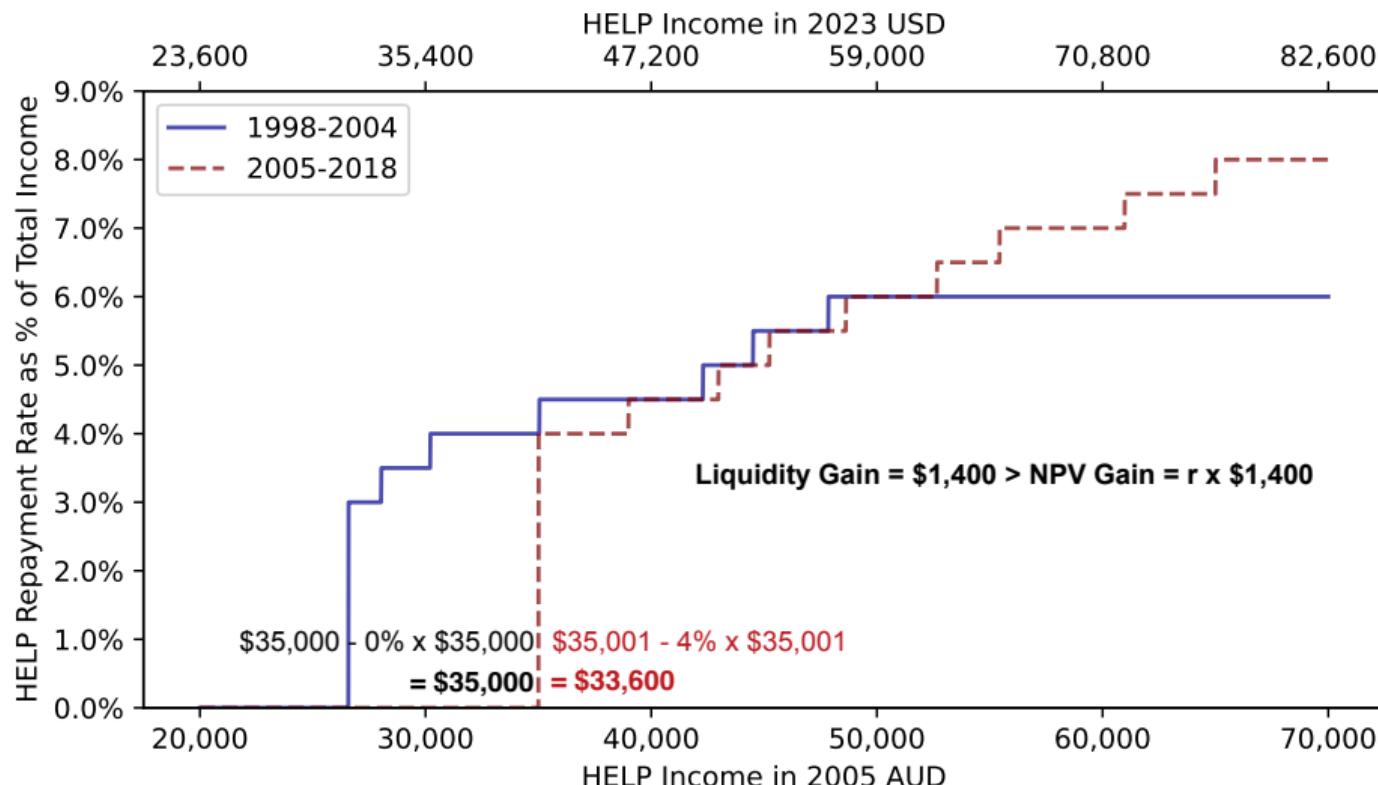
# REPAYMENT THRESHOLD INCREASES AVERAGE REPAYMENT RATE



# REPAYMENT THRESHOLD INCREASES LIQUIDITY MORE THAN WEALTH



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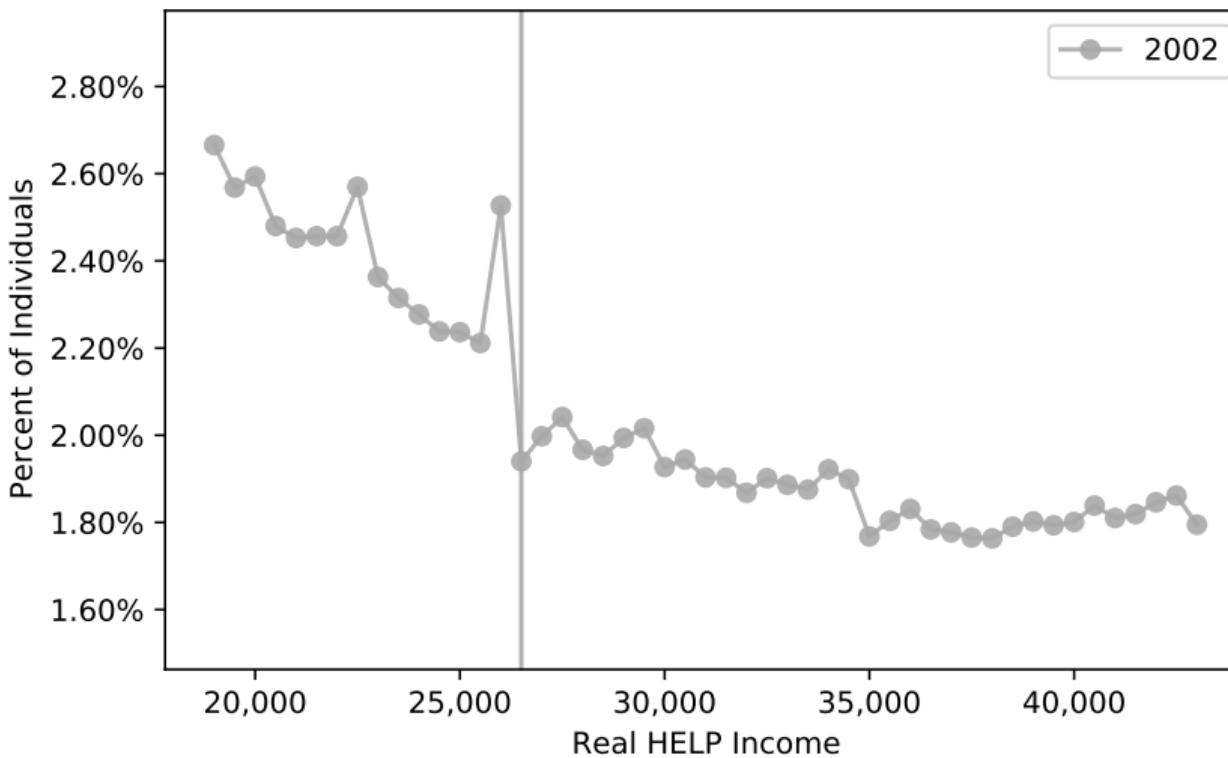
Note: policy change applied to new and existing debtholders

▶ Marginal Rates   ▶ Payments   ▶ News   ▶ Occupations

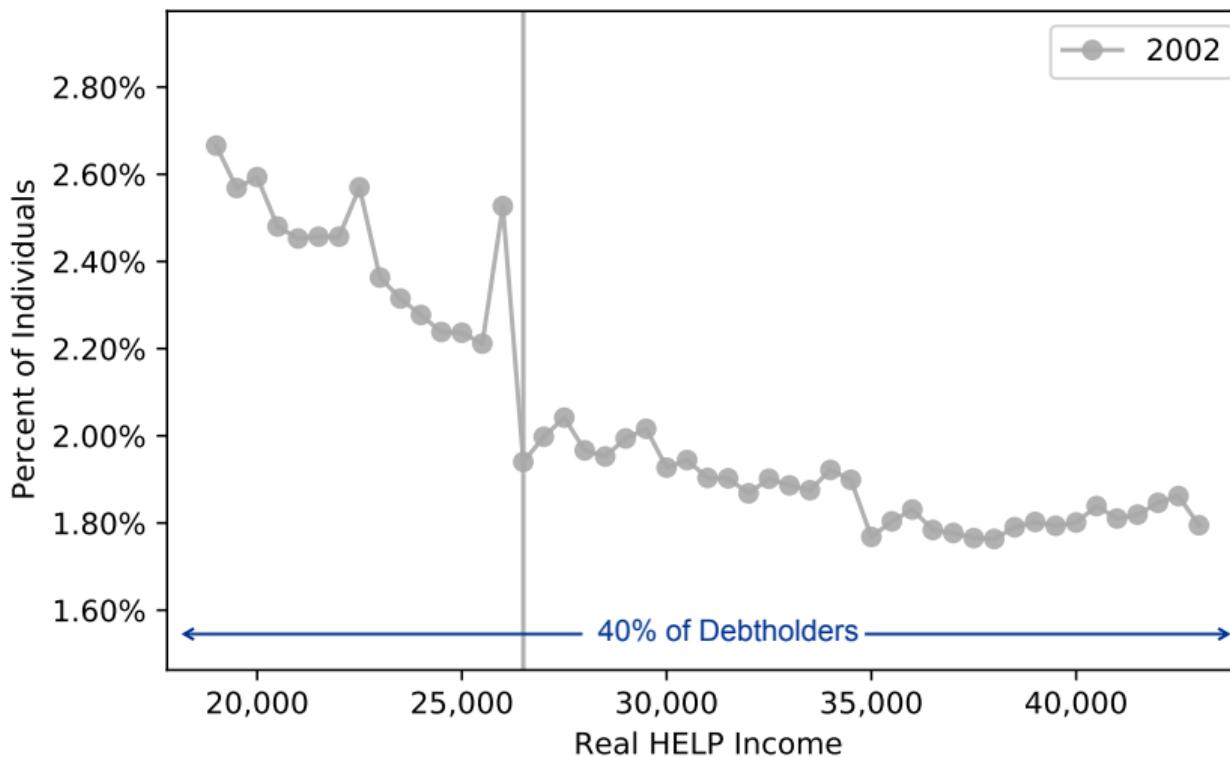
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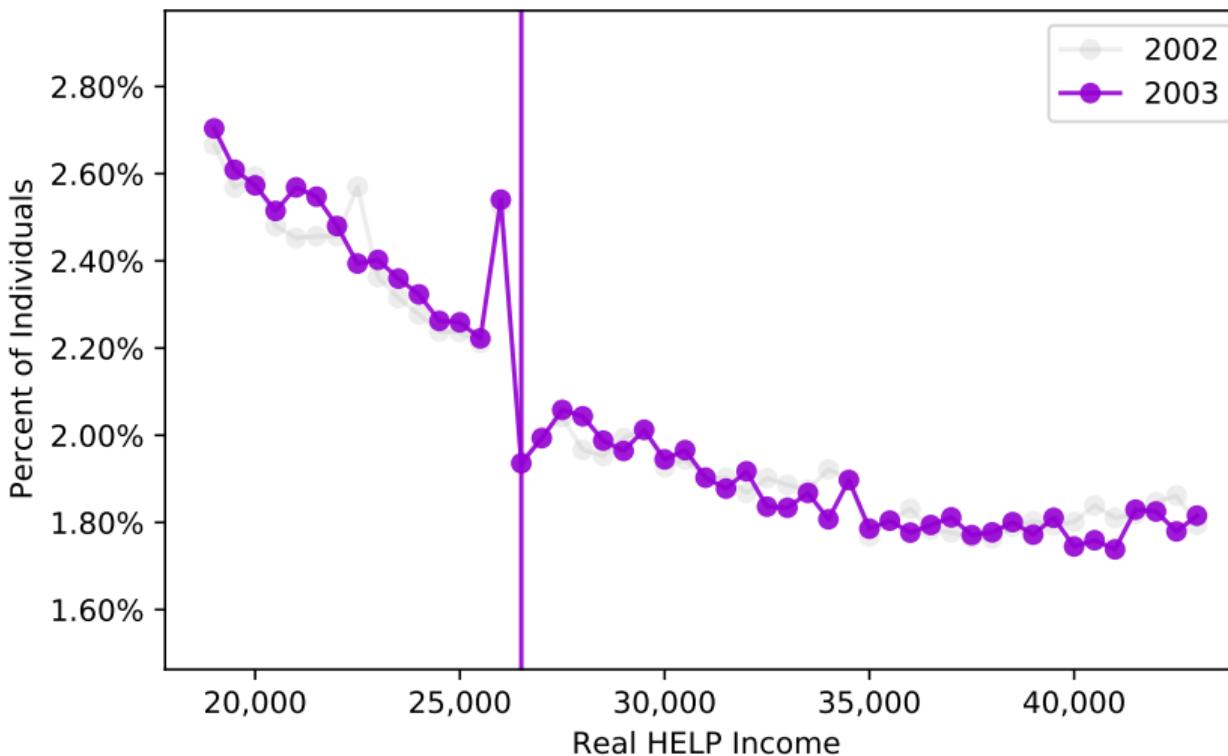
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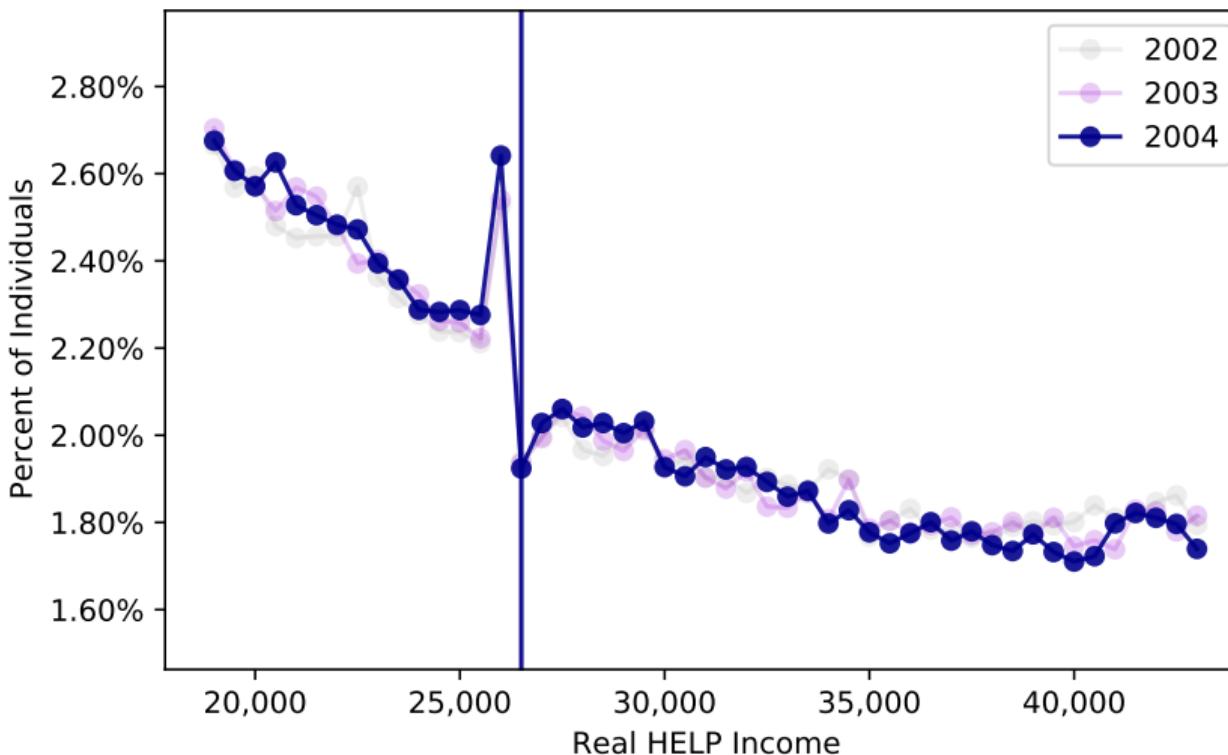
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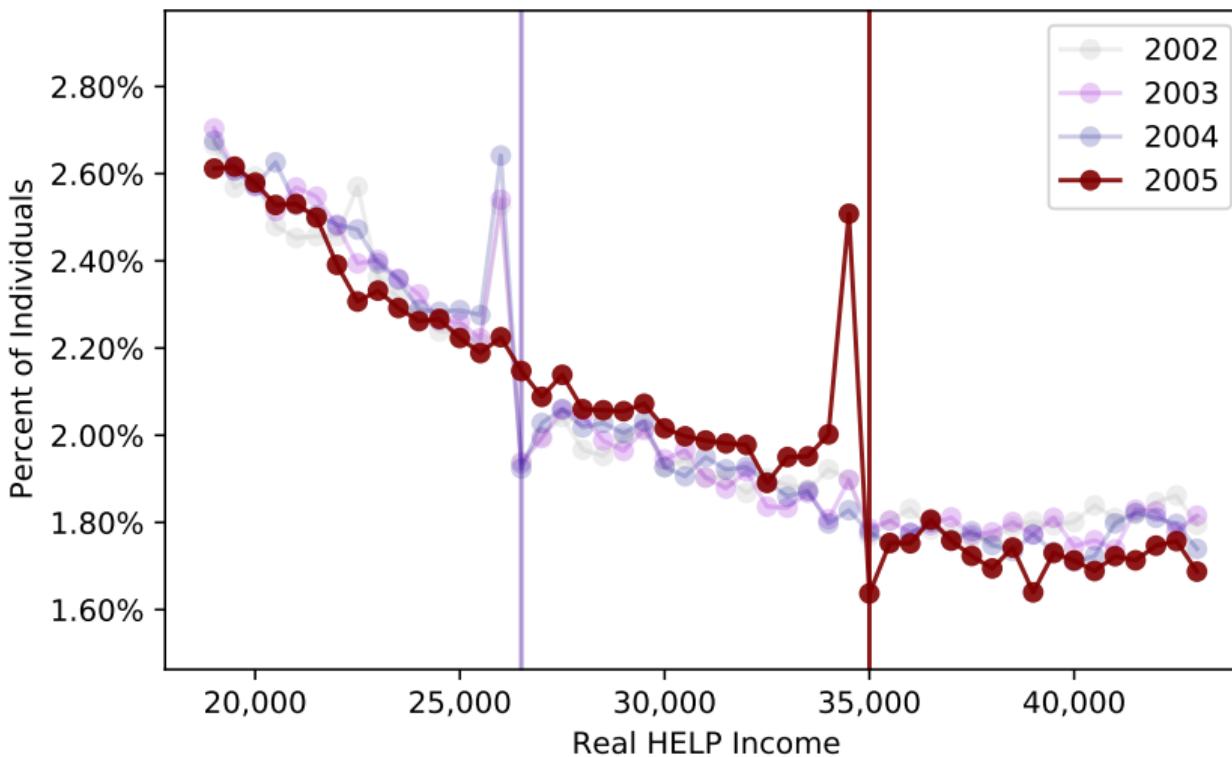
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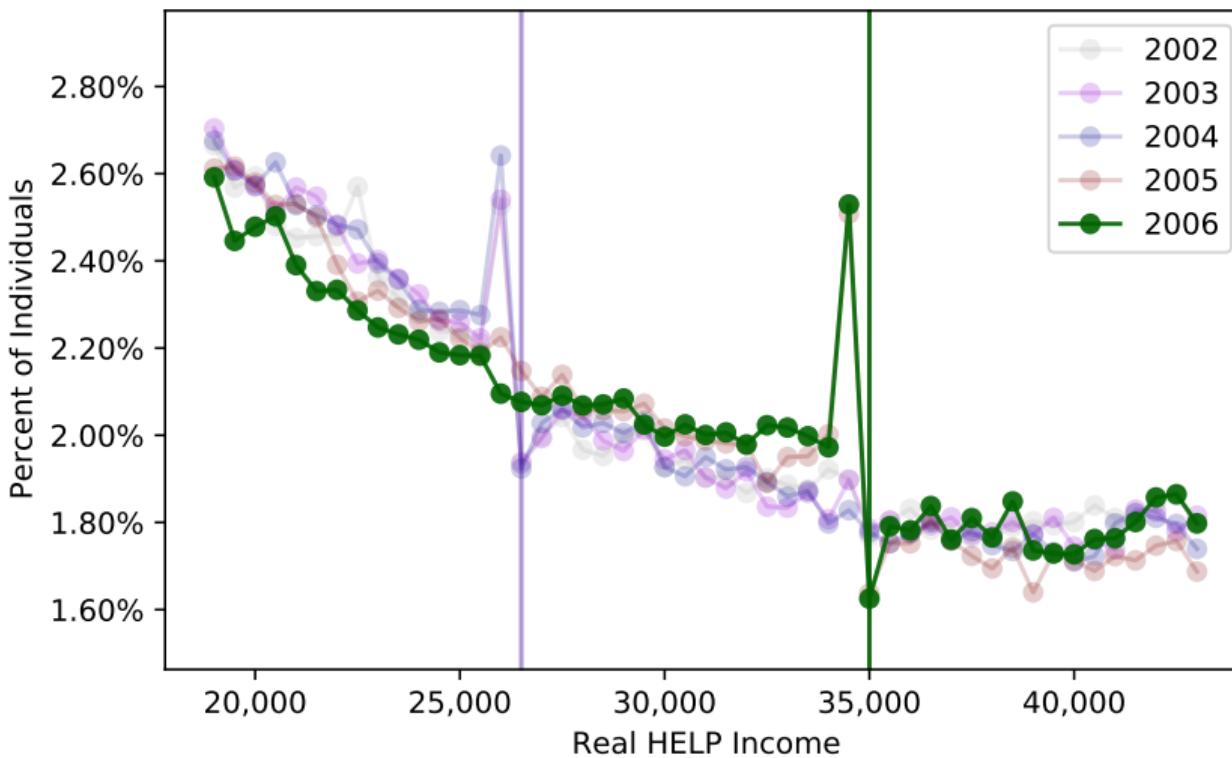
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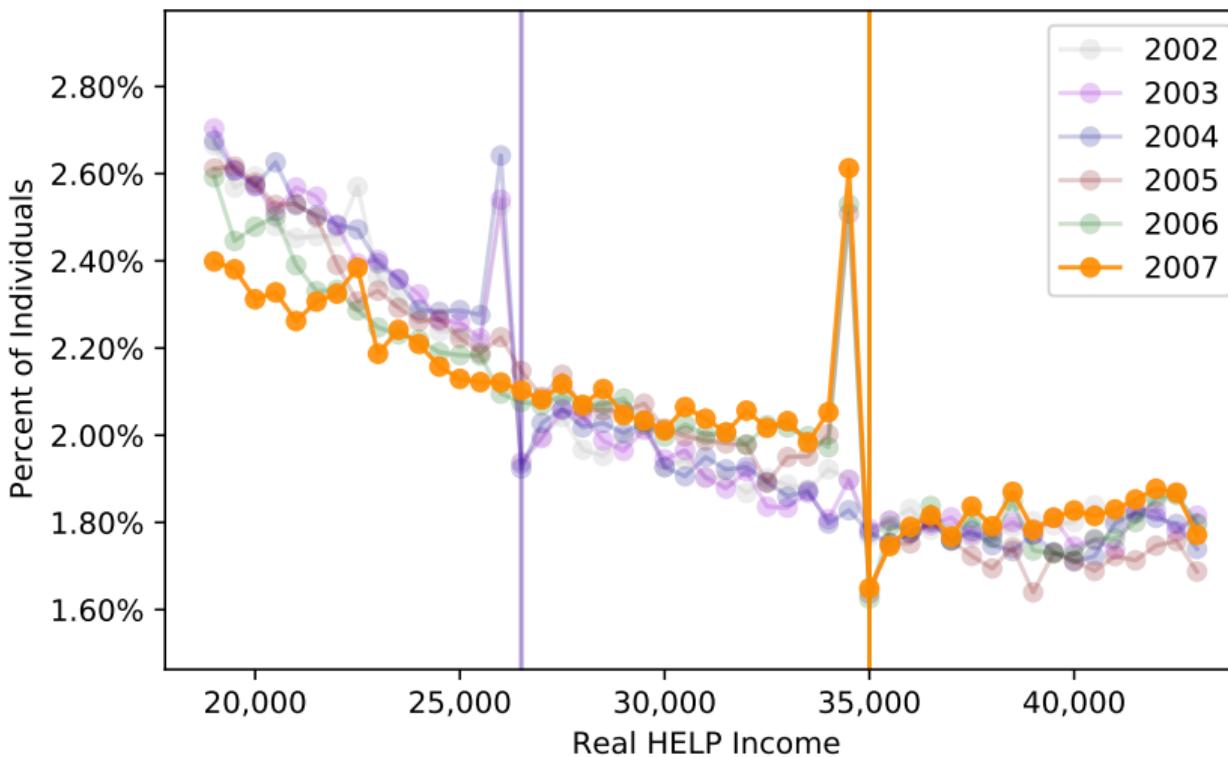
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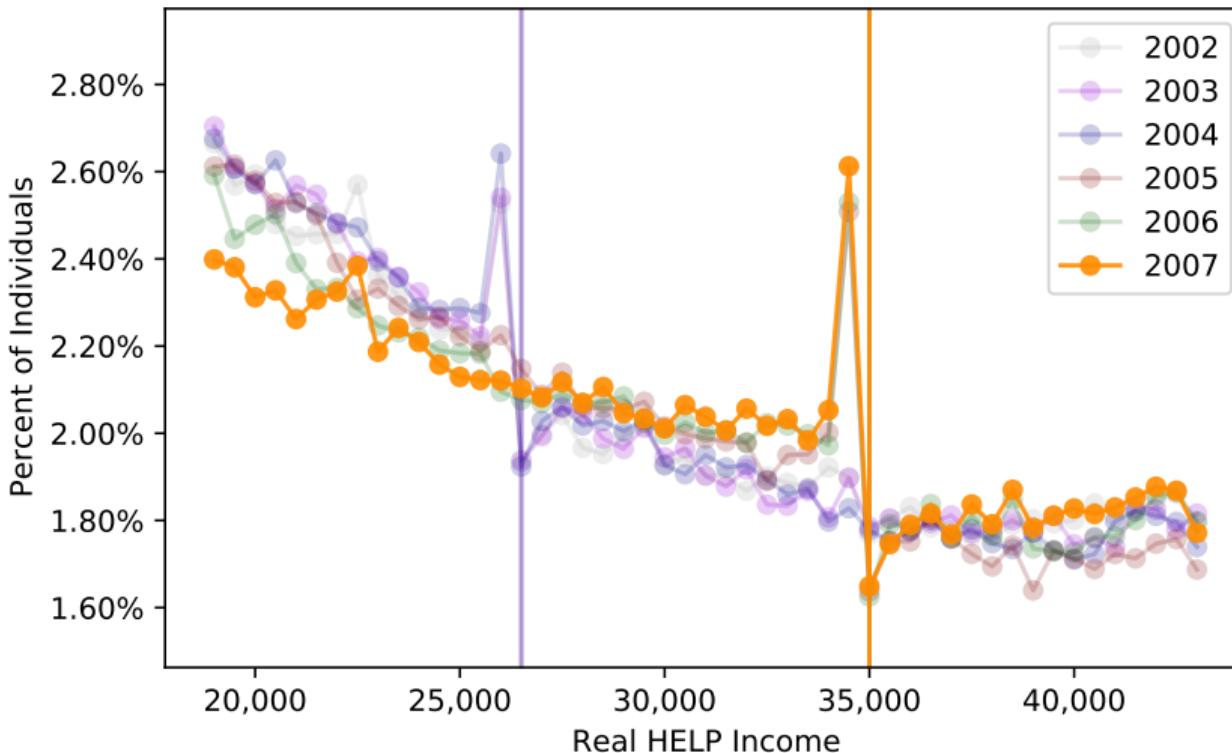
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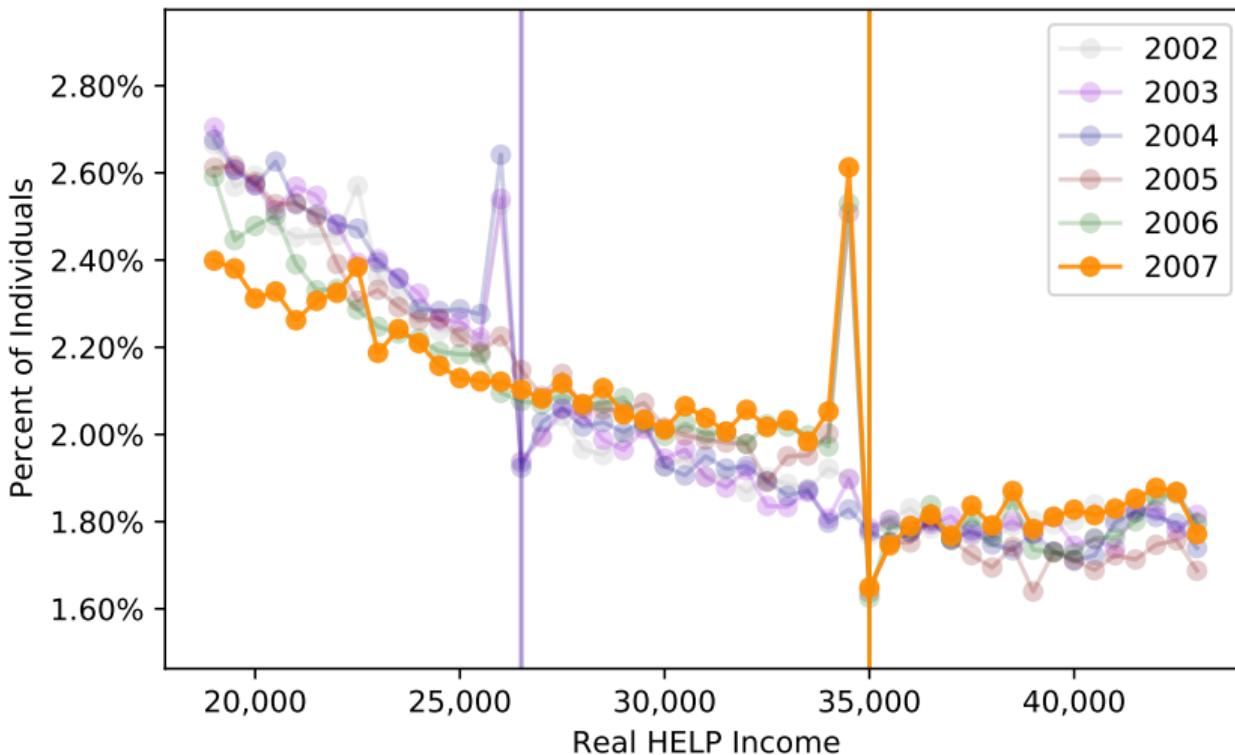


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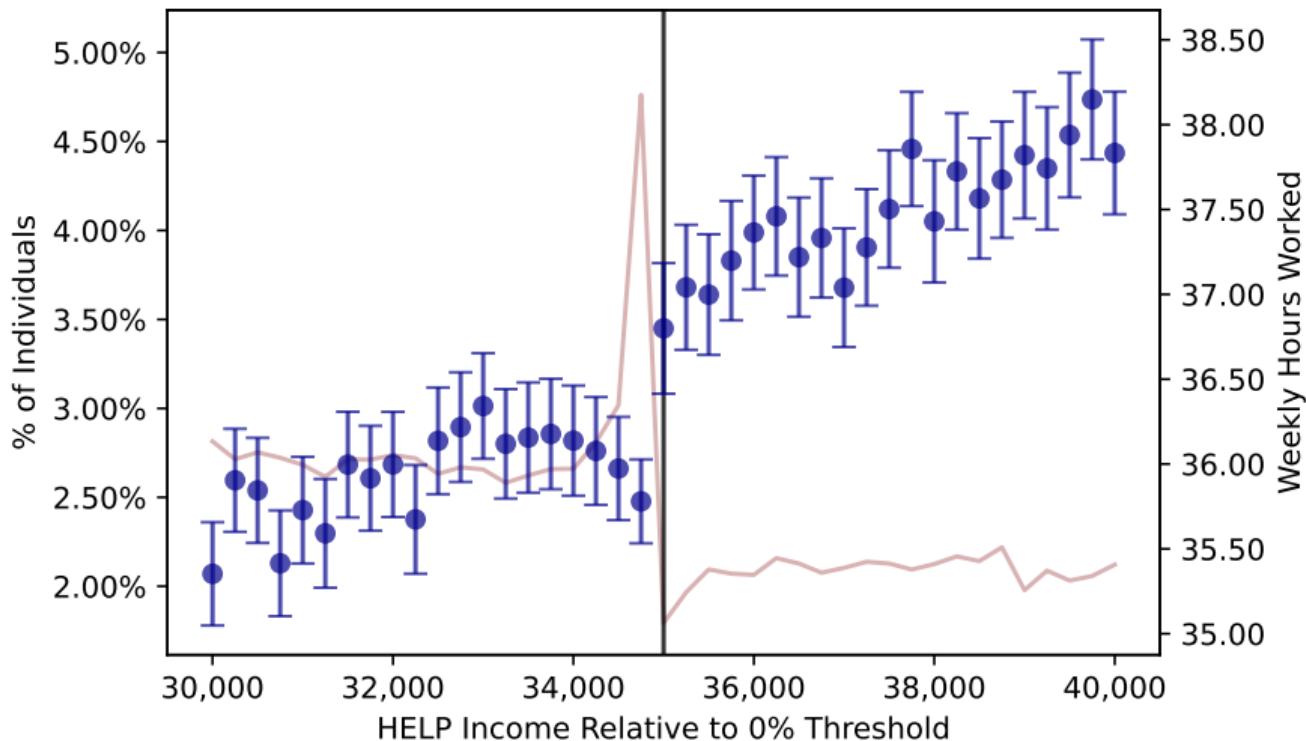
▶ Source

▶ Non-Debt

▶ Labor

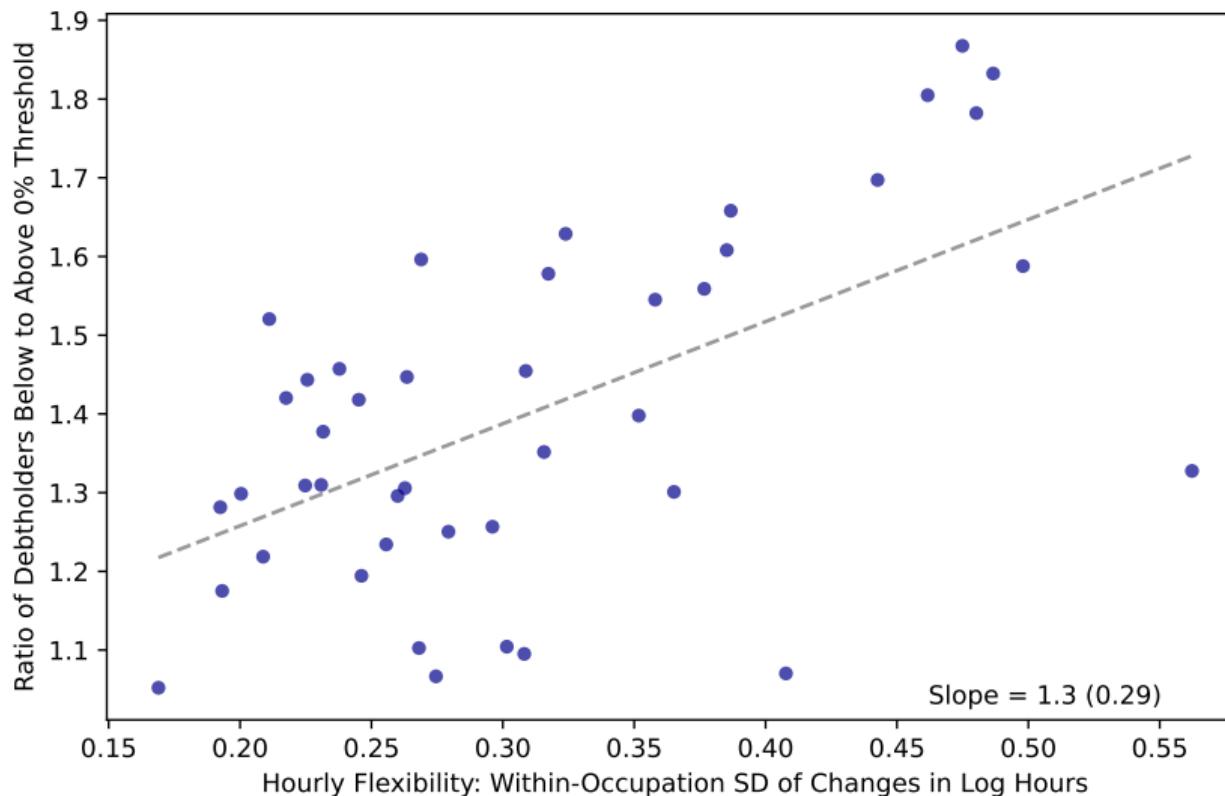
▶ vs Tax

# 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

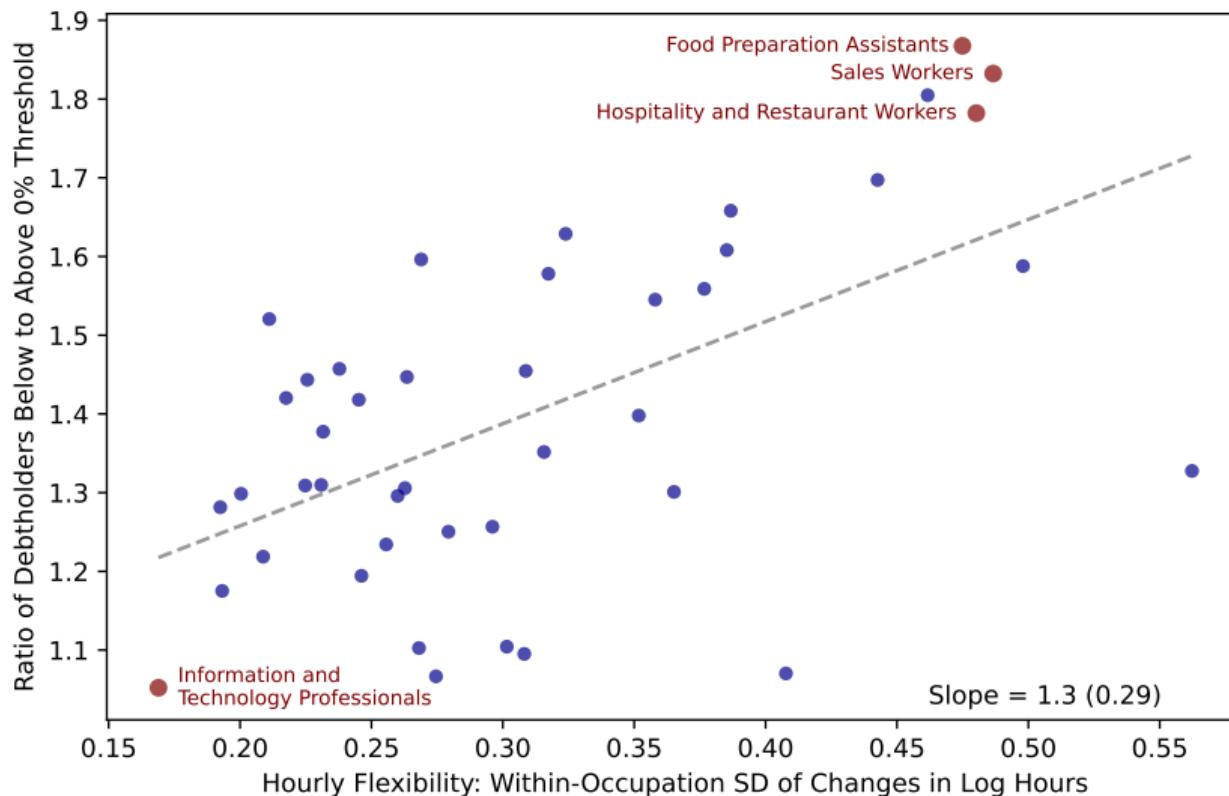
► Slope

► Table

► Profiles

► Additional Results

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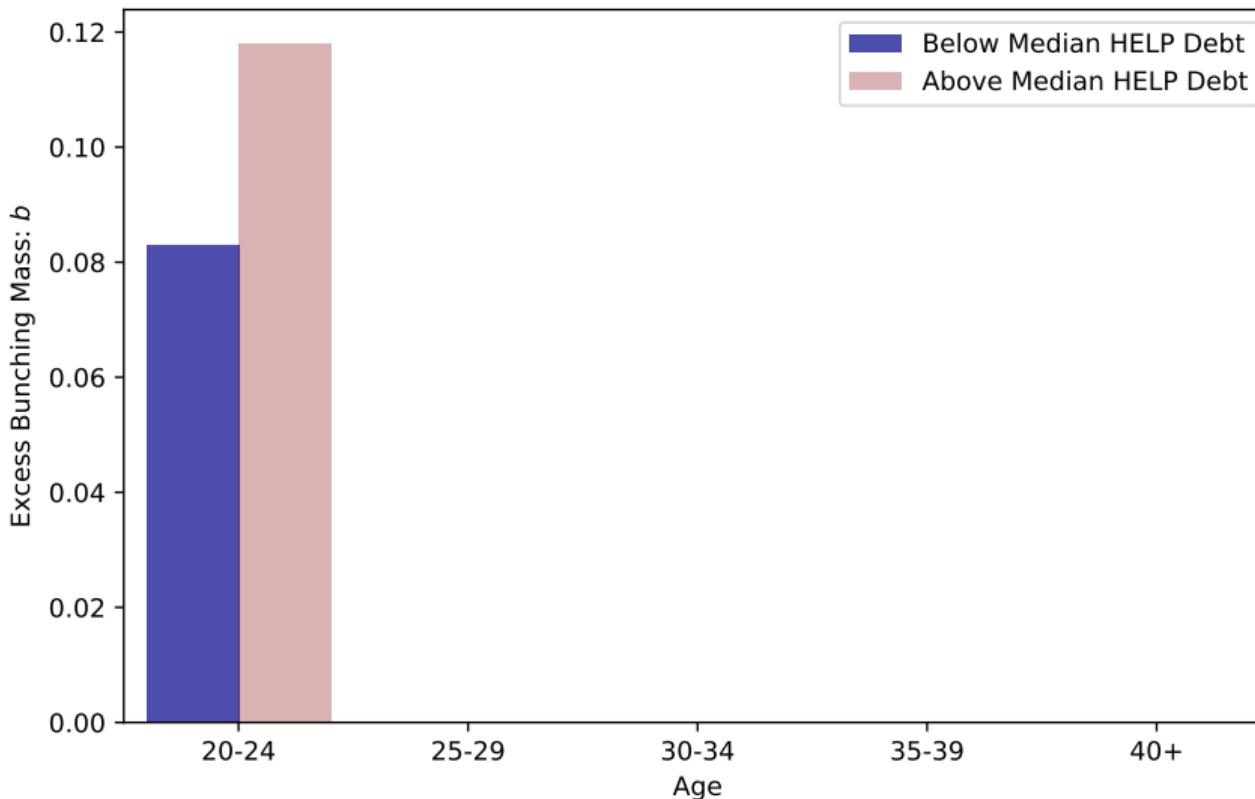
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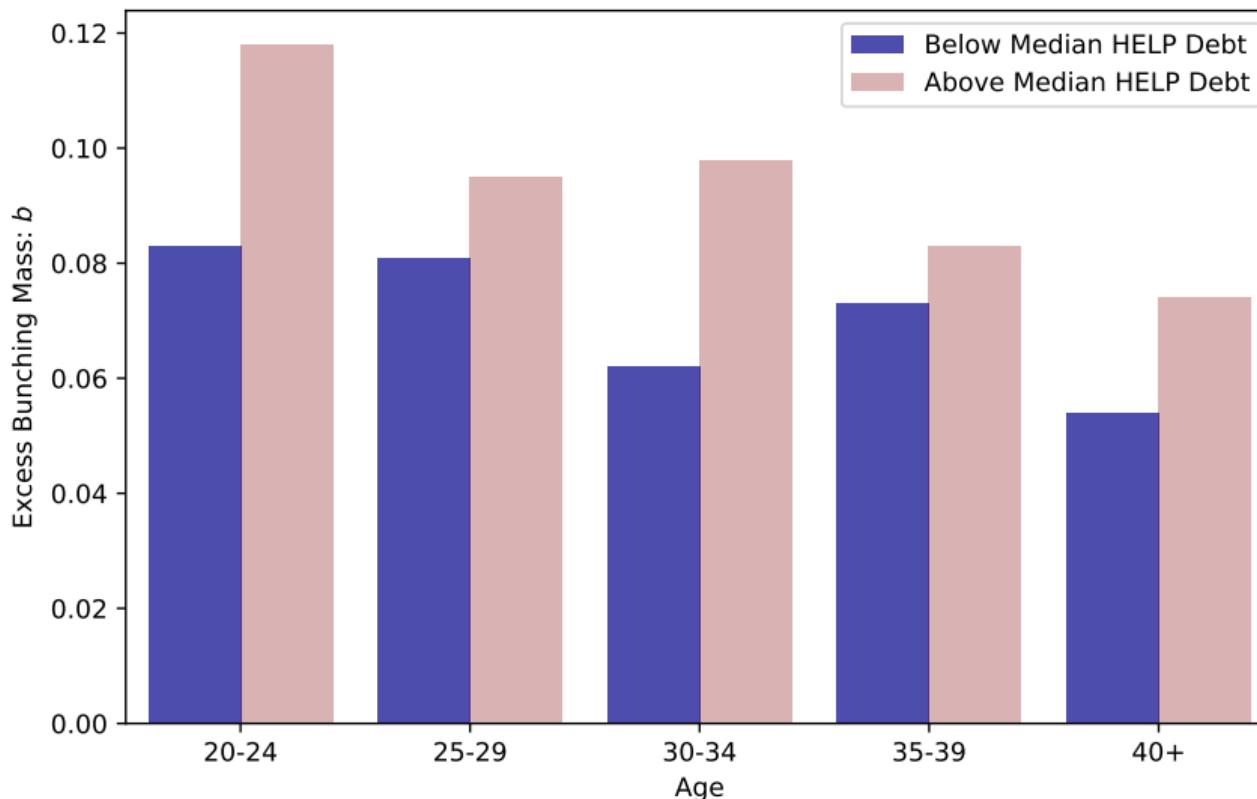
# BUNCHING INCREASES WITH DEBT



Note: confidence intervals omitted due to small size

► *b* Details

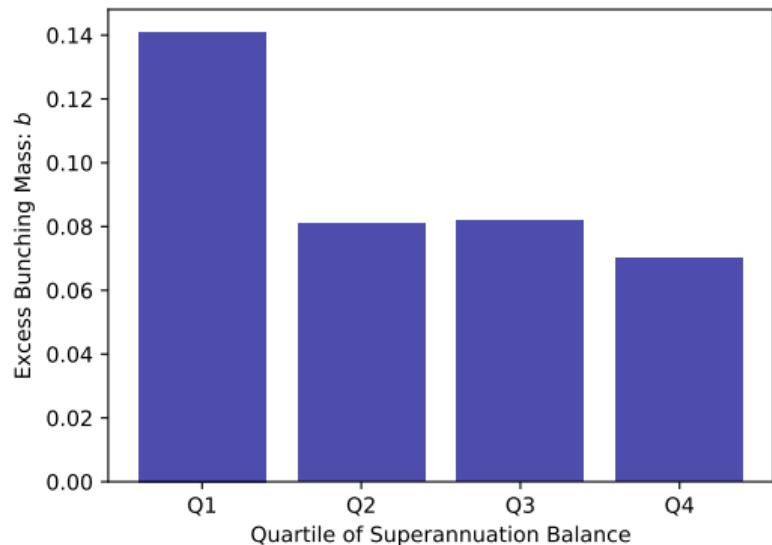
# BUNCHING INCREASES WITH DEBT AND DECREASES WITH AGE



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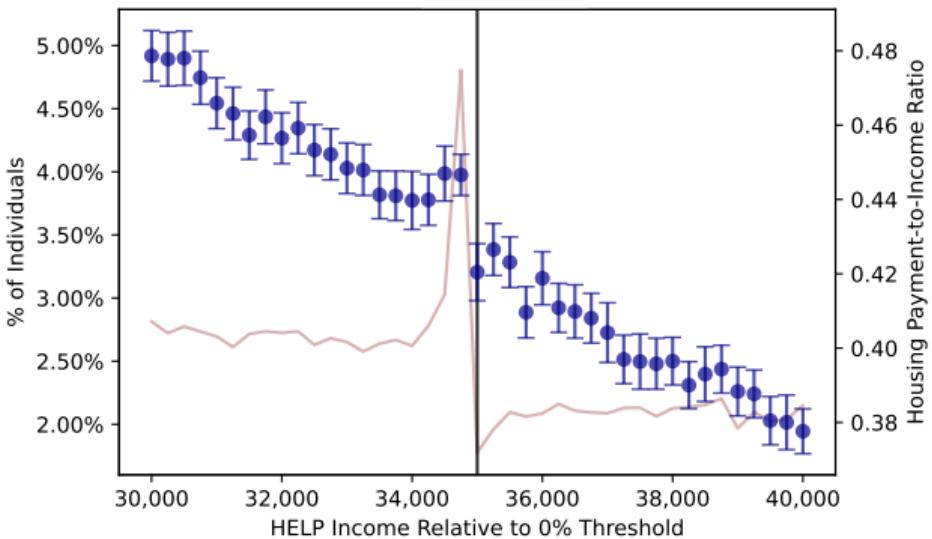
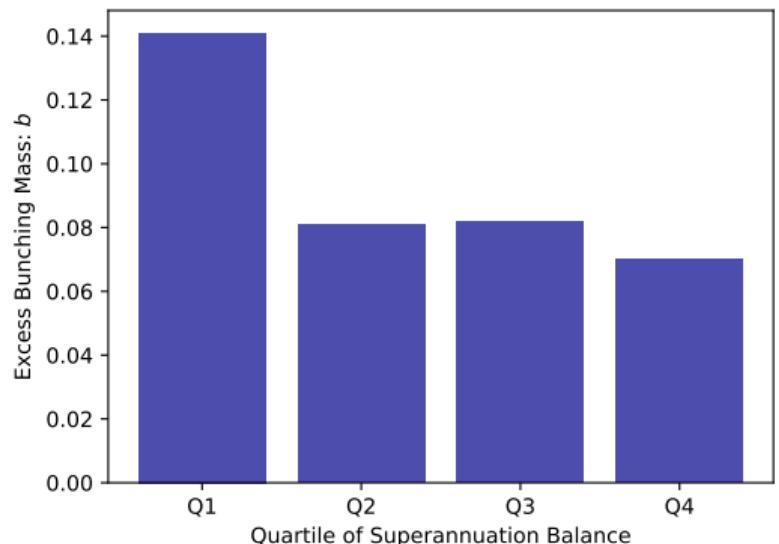
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# BUNCHING INCREASES WITH PROXIES FOR LIQUIDITY CONSTRAINTS



► Within Age    ► House Prices

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## Facts about moral hazard:

► 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
  - Liquidity: increases with liquidity demands, decreases with retirement wealth
  - P(repayment): increases with debt, decreases with wage growth and peak 
- 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

Life cycle model with debt + incomplete markets + endogenous labor supply  
⇒ demand for insurance                                                                                  ⇒ moral hazard

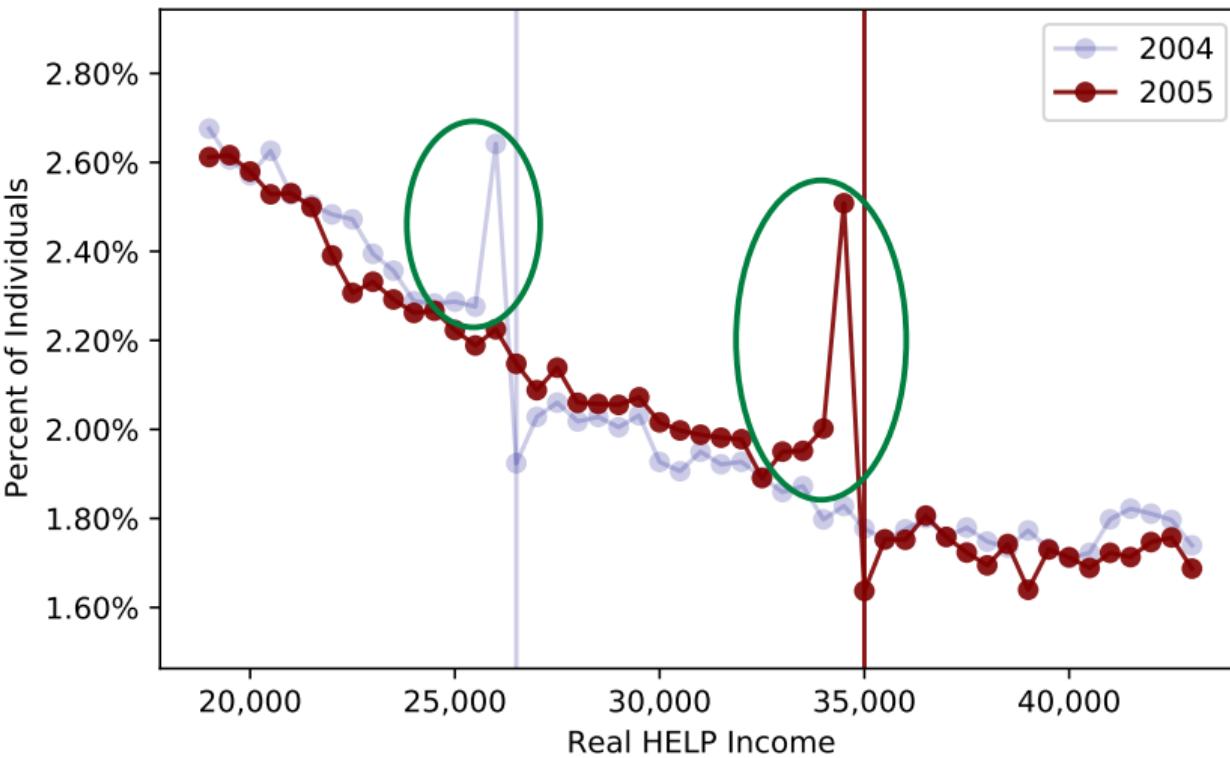
Life cycle model with debt + incomplete markets + endogenous labor supply

- Overlapping generations born at 22 with heterogeneous assets, wage, and debt
- From 22 to 64, individuals choose consumption,  $c_a$ , and labor supply,  $\ell_a$ 
  - 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  $c_a$

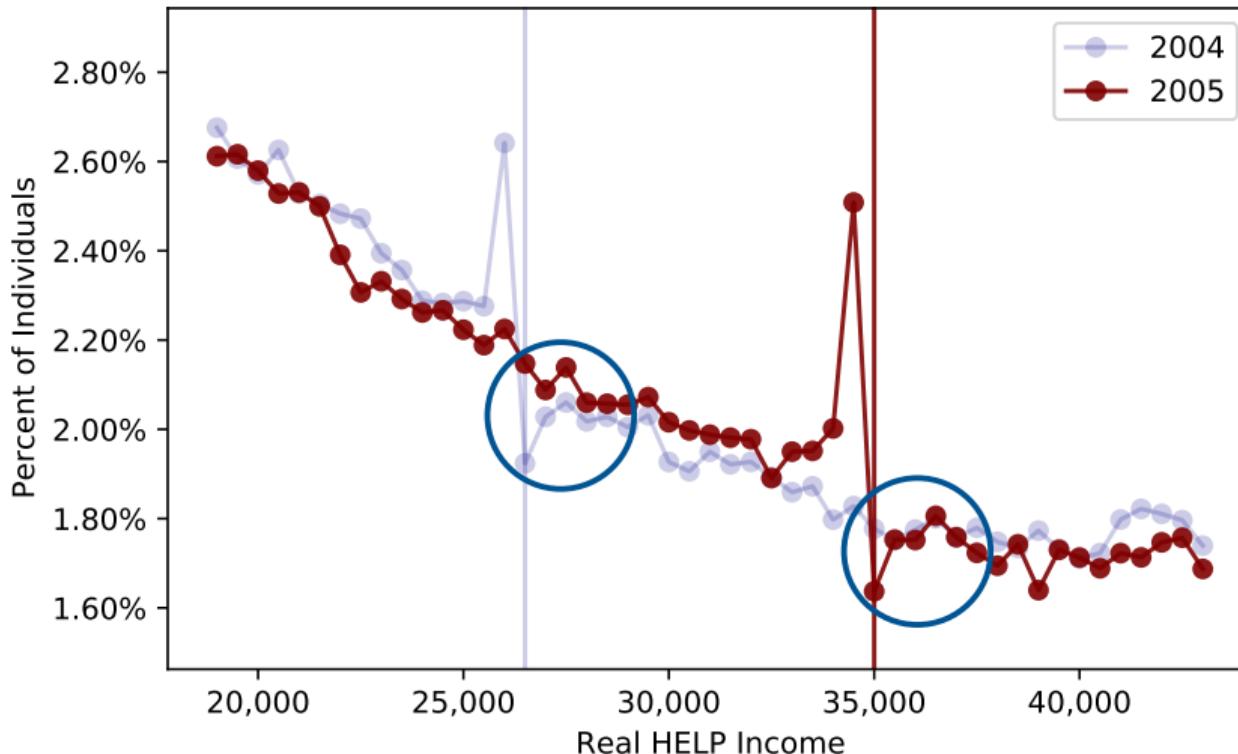
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- **Government**
  - Revenues: progressive income taxes, debt repayments
  - Expenses: means-tested unemployment benefits & retirement pension, initial debt

# 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  $\ell_a$  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  $\lambda$  hit by shock and adjust  $\ell_a$ , 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  $\ell_a \neq \ell_{a-1}$
    - E.g., real or psychological costs of changing hours/jobs

# LABOR SUPPLY OPTIMIZATION FRICTIONS

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    - E.g., real or psychological costs of changing hours/jobs
- 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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$$V_a(\mathbf{s}_a) = \max_{\substack{A_{a+1} \geq \underline{A}_{a+1}, \\ \ell_a}} \underbrace{c_a - \kappa \frac{\ell_a^{1+\phi^{-1}}}{1 + \phi^{-1}}}_{\text{utility of consumption} \\ \& \text{disutility of labor}}$$

# OPTIMIZATION PROBLEM OF INDIVIDUALS HIT BY CALVO SHOCK

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

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

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

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

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

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

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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

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

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

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

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

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

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

- $\theta_a$  = permanent income =  $\rho \theta_{a-1} + \nu_a + \alpha \log \ell_{a-1}$     $\nu_a \sim N(0, \sigma_\nu^2)$
- $\epsilon_a$  = 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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$$\mathbf{s}_a = (a \quad t \quad A_a \quad D_a \quad \theta_a \quad \epsilon_a \quad \ell_{a-1} \quad \omega_a)$$

- $\ell_{a-1}$  = labor supply from previous period
- $\omega_a$  = Calvo shock that determines whether  $\ell_a$  can be adjusted  $\sim$  Bernoulli( $\lambda$ )

# 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:
  - $\theta_0$  = 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

$$\text{Parameters} = \left( \quad \right)$$

- **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

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

- **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

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

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- 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	$\phi$	0.114
Fixed adjustment cost	$f$	\$377
Calvo parameter	$\lambda$	0.183
Time discount factor	$\beta$	0.973
Labor supply scaling parameter	$\kappa$	0.560
Wage profile parameters	$\delta_0$	8.922
	$\delta_1$	0.073
	$\delta_2$	-0.001
	$\delta_0^E$	-0.487
	$\delta_1^E$	0.020
Persistence of permanent shock	$\rho$	0.930
Standard deviation of permanent shock	$\sigma_\nu$	0.236
Standard deviation of transitory shock	$\sigma_\epsilon$	0.130
Standard deviation of individual FE	$\sigma_i$	0.599

► Comparison with Literature

► All Results with SE

# ESTIMATION RESULTS

Parameter		Estimation	
		Baseline	No Frictions
Labor supply elasticity	$\phi$	0.114	0.005
Fixed adjustment cost	$f$	\$377	.
Calvo parameter	$\lambda$	0.183	.
Time discount factor	$\beta$	0.973	0.996
Labor supply scaling parameter	$\kappa$	0.560	0.030
Wage profile parameters	$\delta_0$	8.922	9.862
	$\delta_1$	0.073	0.111
	$\delta_2$	-0.001	-0.002
	$\delta_0^E$	-0.487	-0.294
	$\delta_1^E$	0.020	0.032
Persistence of permanent shock	$\rho$	0.930	0.914
Standard deviation of permanent shock	$\sigma_\nu$	0.236	0.076
Standard deviation of transitory shock	$\sigma_\epsilon$	0.130	0.504
Standard deviation of individual FE	$\sigma_i$	0.599	0.101

► Comparison with Literature

► All Results with SE

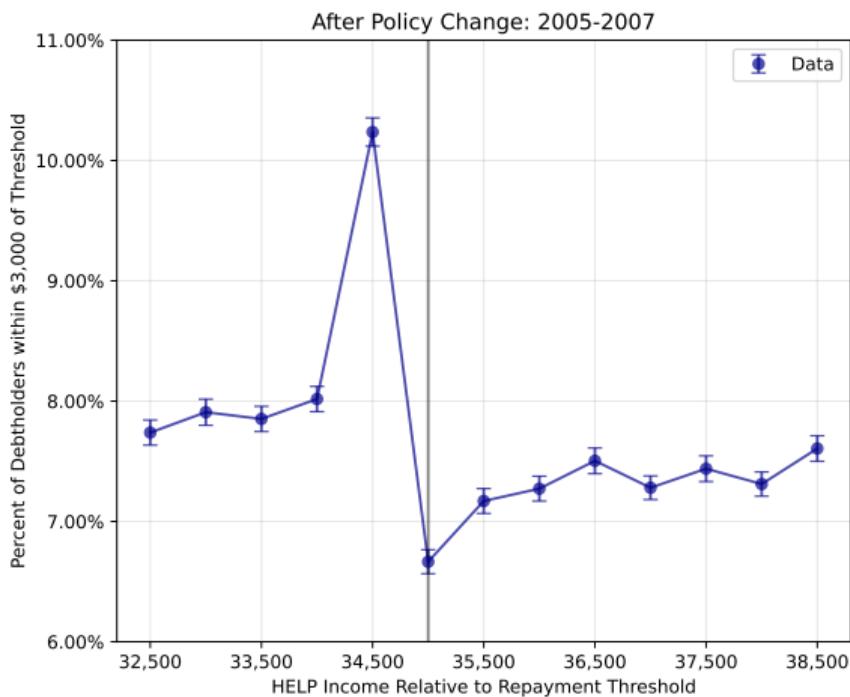
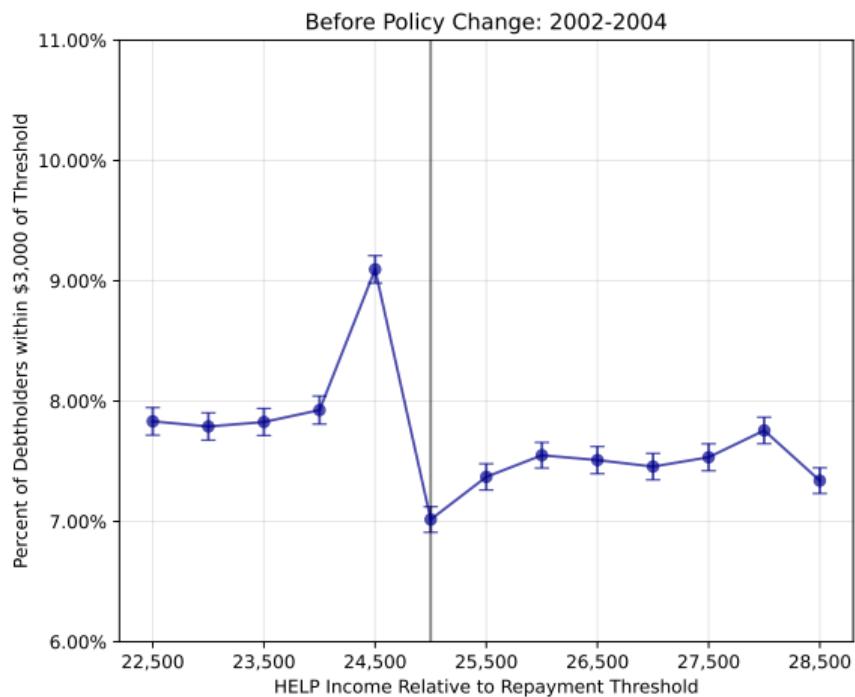
# ESTIMATION RESULTS

Parameter		Estimation		
		Baseline	No Frictions	LBD
Labor supply elasticity	$\phi$	0.114	0.005	0.082
Fixed adjustment cost	$f$	\$377	.	\$762
Calvo parameter	$\lambda$	0.183	.	0.346
Time discount factor	$\beta$	0.973	0.996	0.951
Labor supply scaling parameter	$\kappa$	0.560	0.030	1.242
Wage profile parameters	$\delta_0$	8.922	9.862	9.197
	$\delta_1$	0.073	0.111	0.070
	$\delta_2$	-0.001	-0.002	-0.001
	$\delta_0^E$	-0.487	-0.294	-0.480
	$\delta_1^E$	0.020	0.032	0.018
Persistence of permanent shock	$\rho$	0.930	0.914	0.889
Standard deviation of permanent shock	$\sigma_\nu$	0.236	0.076	0.288
Standard deviation of transitory shock	$\sigma_\epsilon$	0.130	0.504	0.064
Standard deviation of individual FE	$\sigma_i$	0.599	0.101	0.625

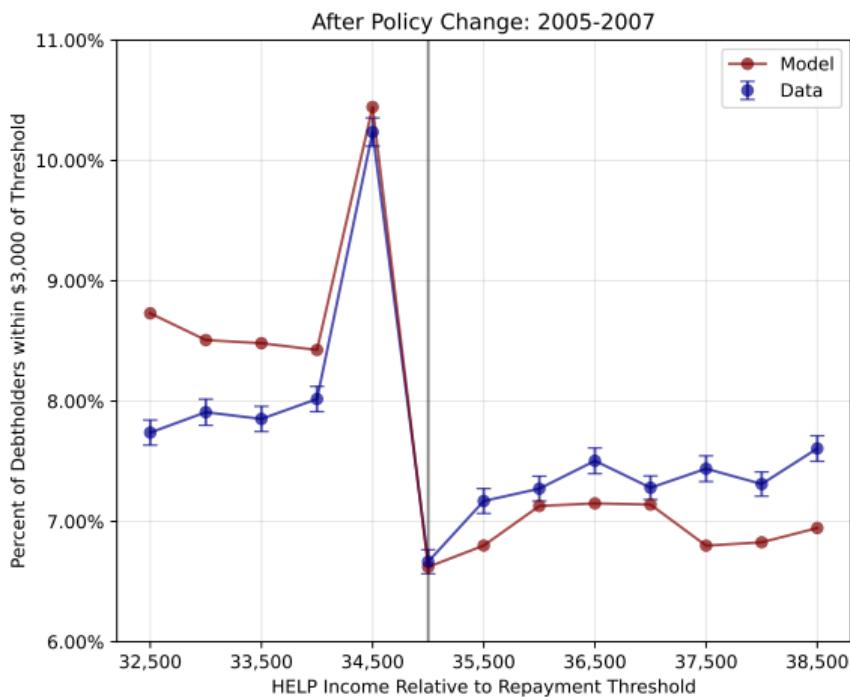
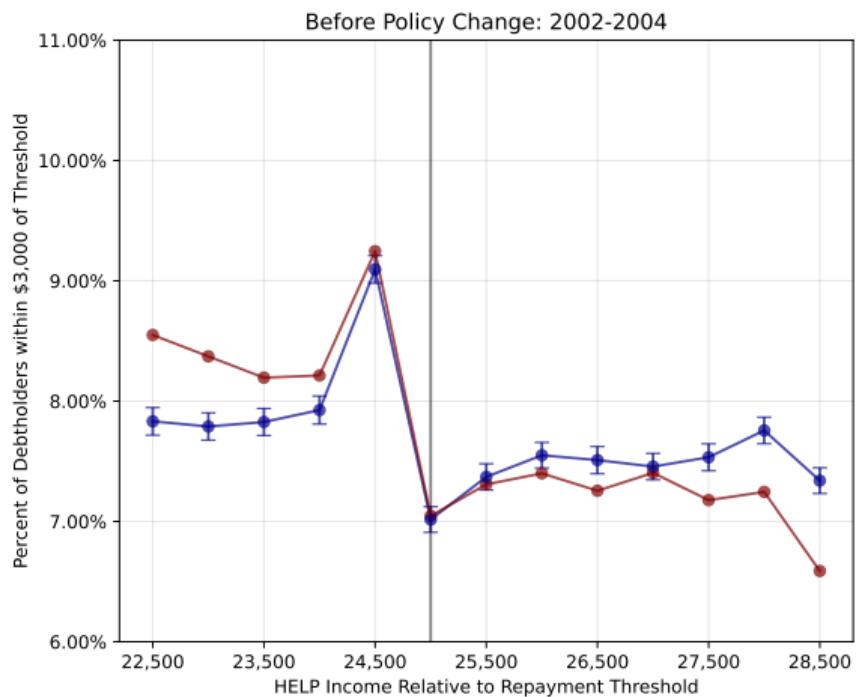
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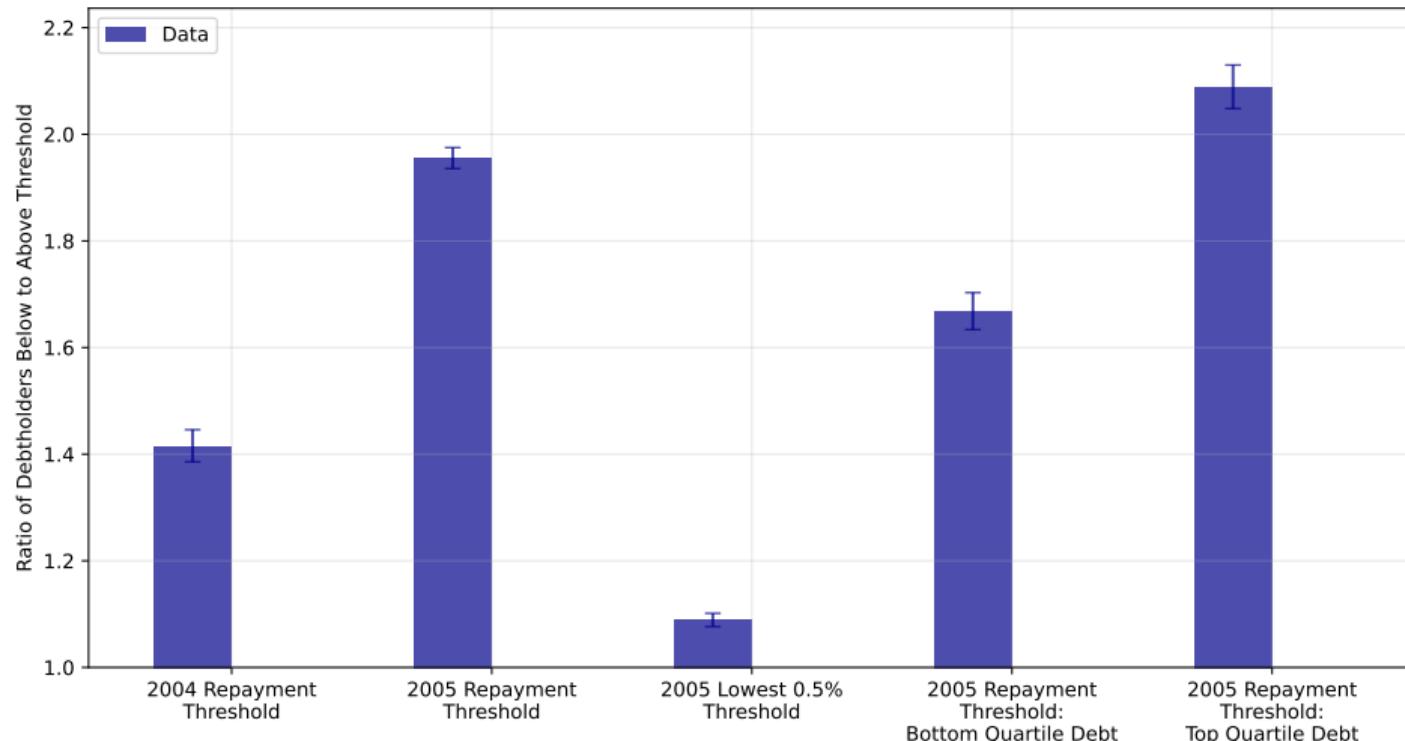
# MODEL FIT: BUNCHING BEFORE AND AFTER POLICY CHANGE



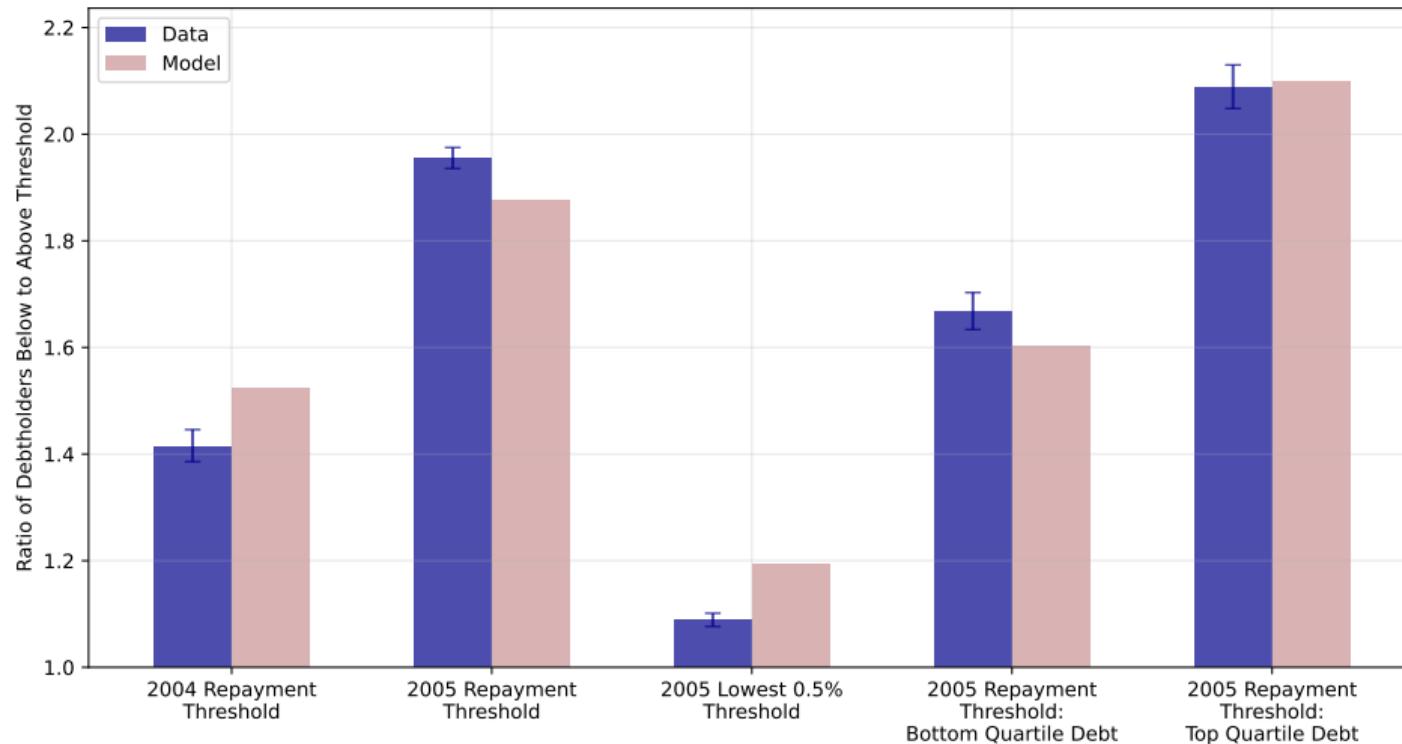
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# MODEL FIT: BUNCHING HETEROGENEITY



# 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 and Fiscal Impacts 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

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- **Step 1: existing** income-contingent loans vs. fixed repayment (not budget-neutral)
  - Four contracts: HELP 2004, HELP 2005, US Old & New IBR =  $\psi * \max\{y - K, 0\}$
- **Step 2: optimal** income-contingent contracts vs. fixed repayment (budget-neutral)

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- **Step 2: optimal** income-contingent contracts vs. fixed repayment (budget-neutral)
- Note: consider effect of forgiveness in Step 2

# GOVERNMENT BUDGET = EXPECTED DISCOUNTED VALUE OF PAYMENTS

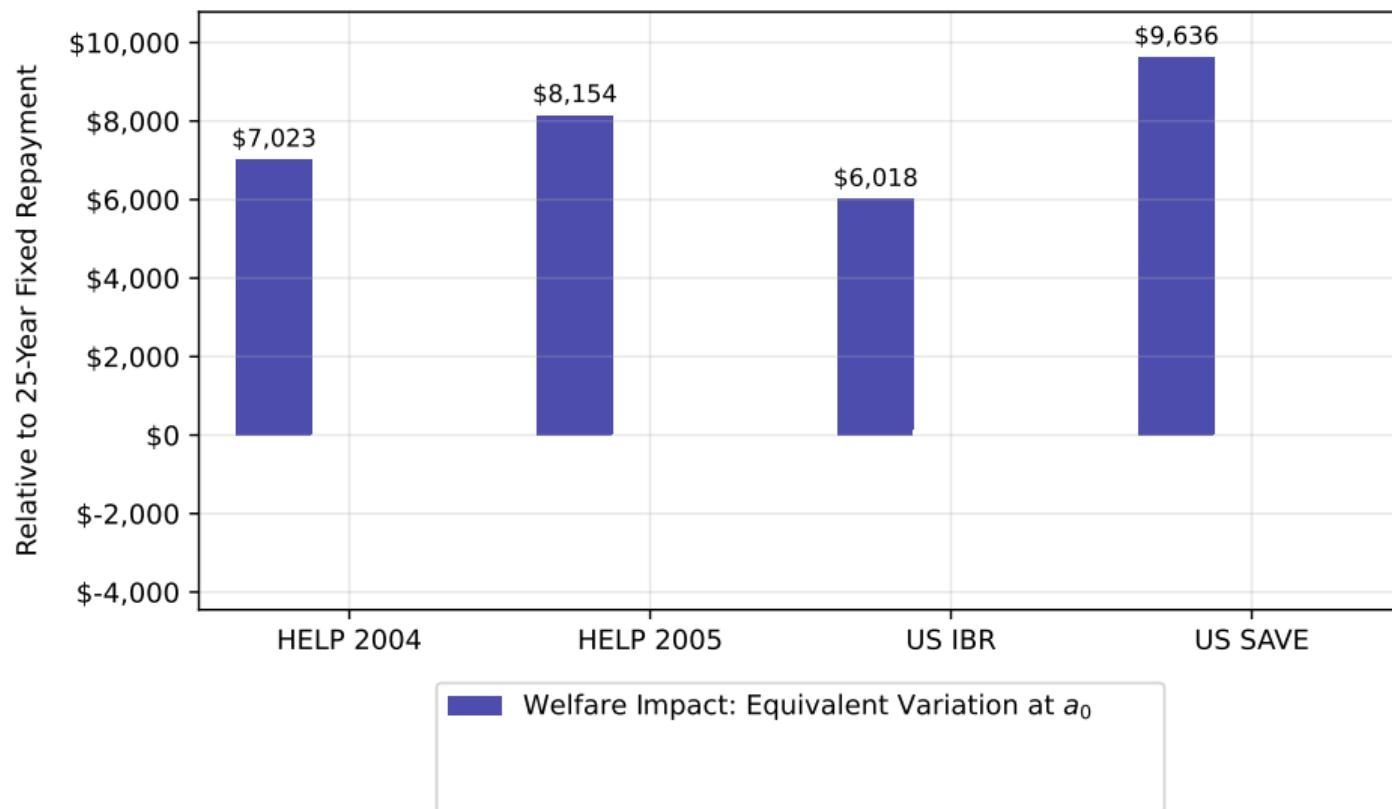
- **Government budget** defined as:

$$\mathcal{G} = \mathbf{E}_0 \sum_{a=a_0}^{a_T} \frac{\text{Repayments}_a + \text{Taxes}_a - \text{Transfers}_a}{\mathcal{R}_a}$$

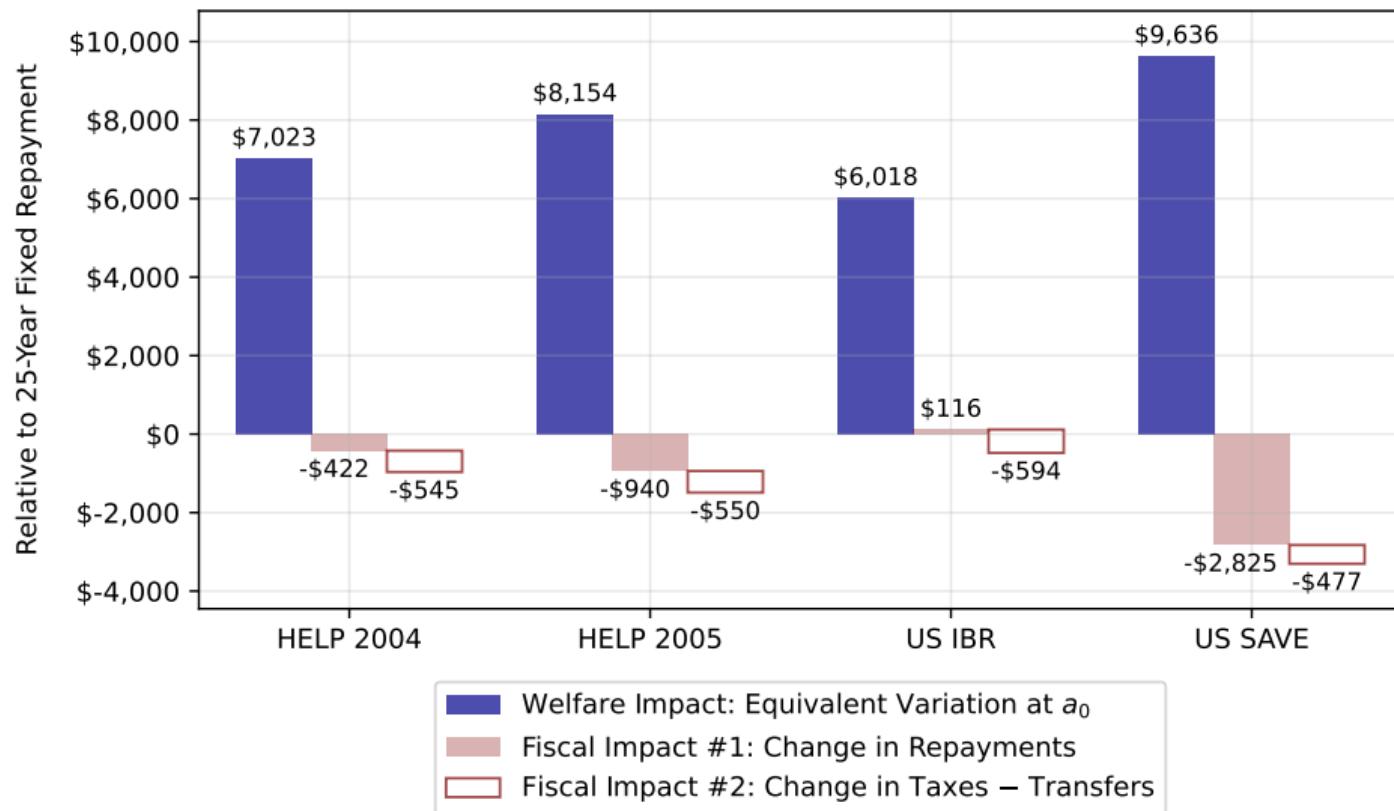
$$\mathcal{R}_a^{-1} = \underbrace{\beta^{a-a_0}}_{\text{individual time preference}} * \underbrace{\prod_{s=0}^{a-a_0} m_s}_{\text{mortality}}$$

- **Benchmark:** 25-Year Fixed Repayment = similar duration, not income-contingent
- Robustness with  $\mathcal{R}_a$  = risk-free rate and  $\mathcal{R}_a$  = risk-free rate + 4%

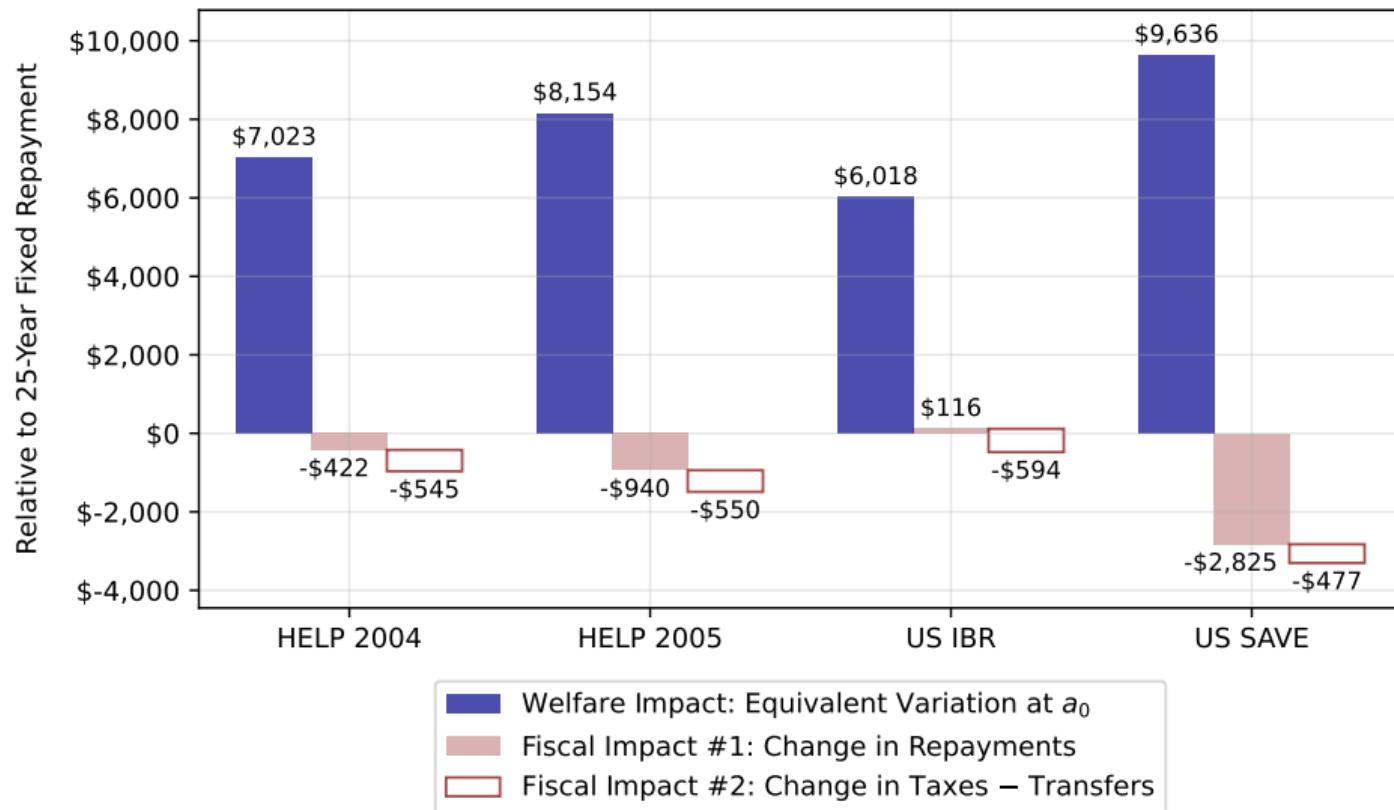
## EXISTING INCOME-CONTINGENT LOANS VS. FIXED REPAYMENT



# EXISTING INCOME-CONTINGENT LOANS VS. FIXED REPAYMENT



# EXISTING INCOME-CONTINGENT LOANS VS. FIXED REPAYMENT



► Decomposition

► MVPF

# CONSTRAINED-OPTIMAL INCOME-CONTINGENT LOANS

- Contracts have different fiscal costs  $\Rightarrow$  need to balance government budget
- **Next:** solve **constrained**-planner's problem to construct contracts with **same cost**

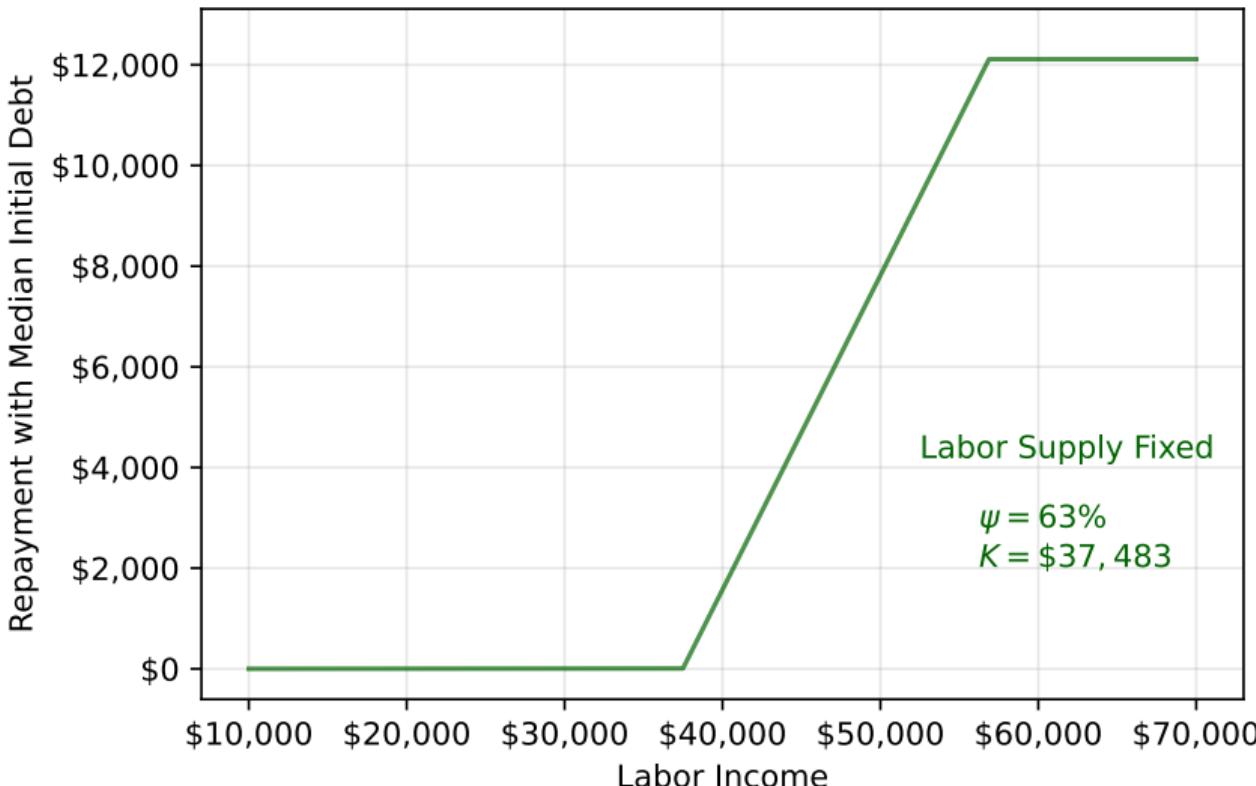
$$\max_{\psi, K} \mathbf{E}_0 \left( V_{a_0}^{1-\gamma} \right)^{\frac{1}{1-\gamma}}$$

subject to:

$$\mathbf{E}_0 \sum_{a=a_0}^{a_T} \frac{\text{Repayments}_a + \text{Taxes}_a - \text{Transfers}_a}{\mathcal{R}_a} \geq \mathcal{G}_{\text{25-Year Fixed}} \quad (1)$$

$$\text{Repayments}_a = \min \{ \psi * \max \{ y_a - K, 0 \}, D_a \} \quad (2)$$

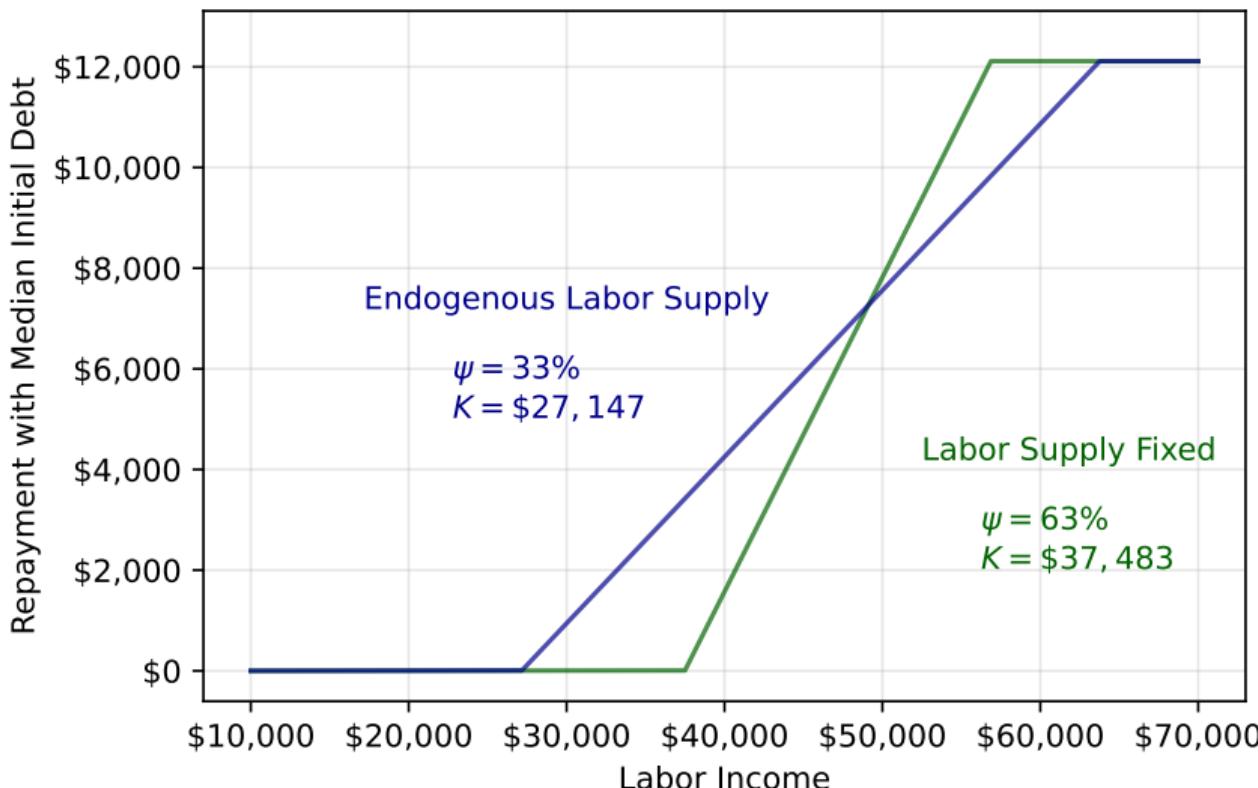
# SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM



► Smooth Contract

► Compare with Existing

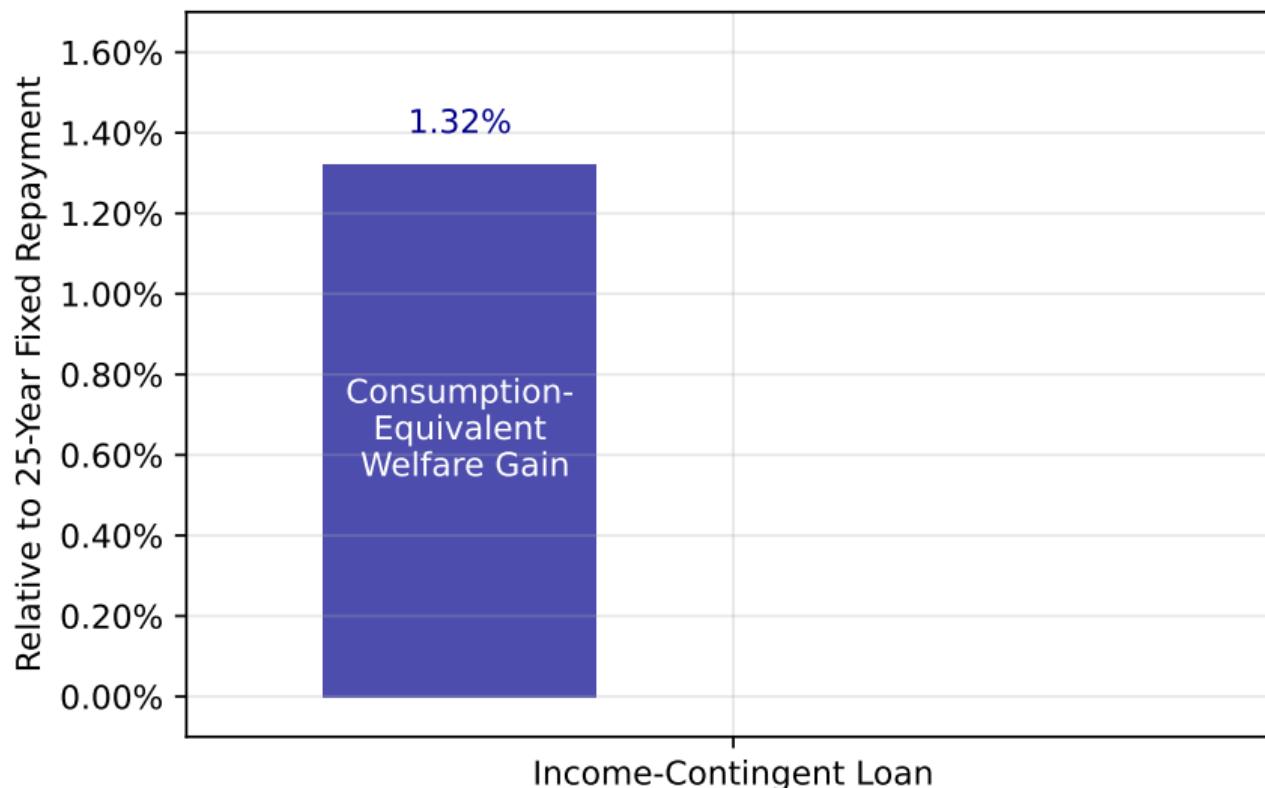
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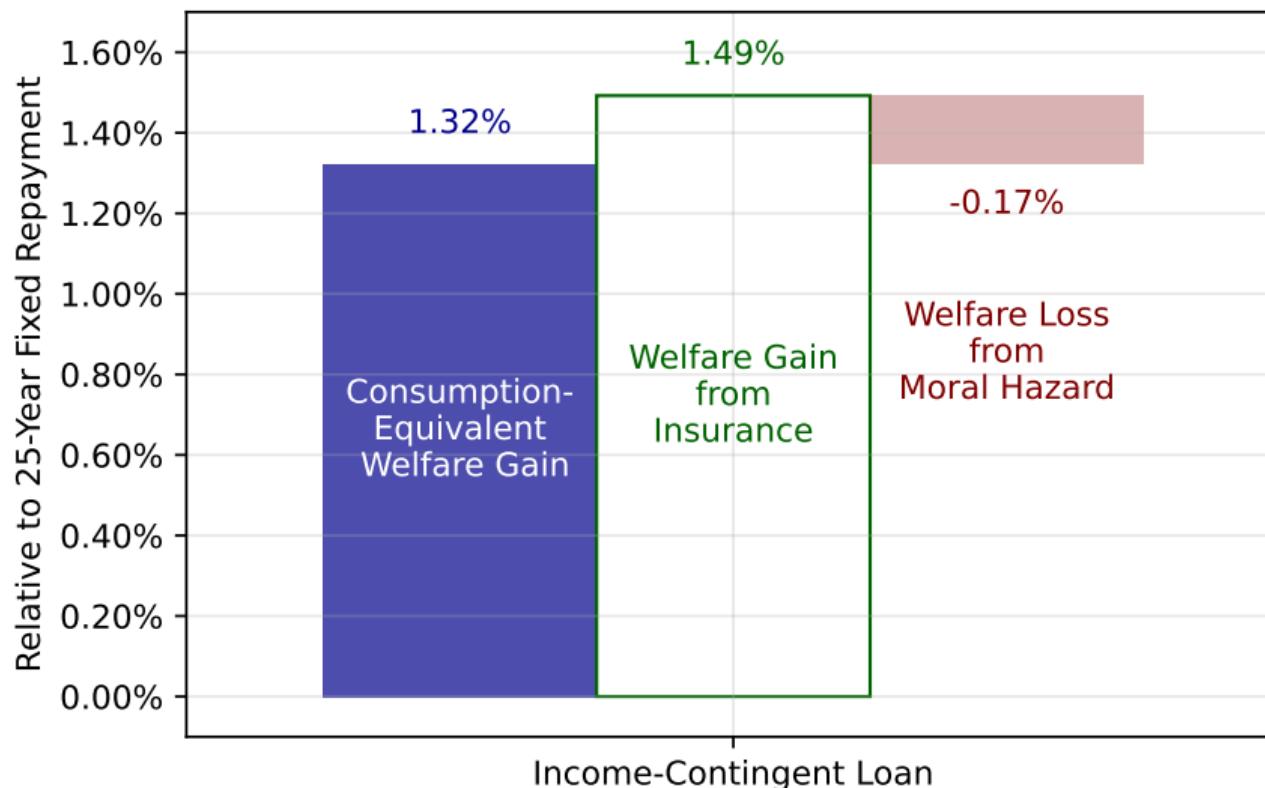
► Smooth Contract

► Compare with Existing

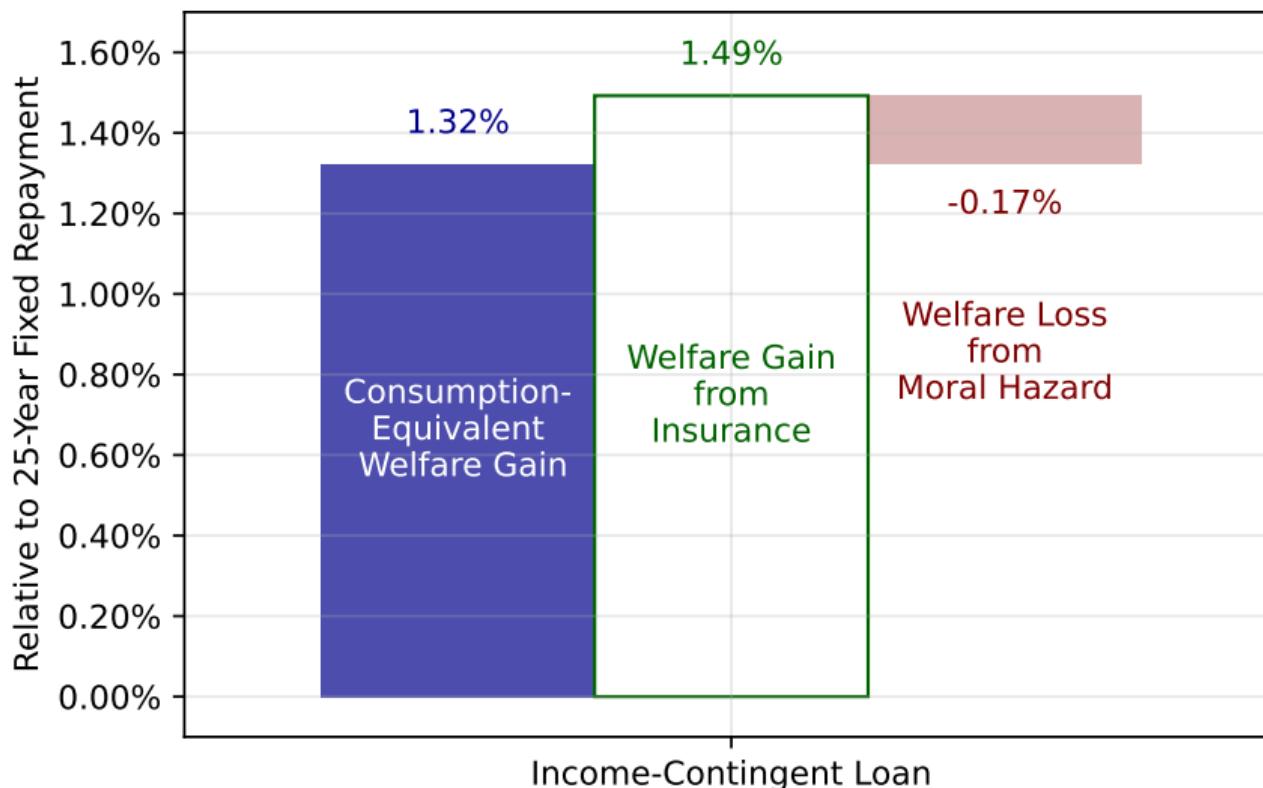
# CONSTRAINED-OPTIMUM = 1.3% INCREASE IN LIFETIME CONSUMPTION



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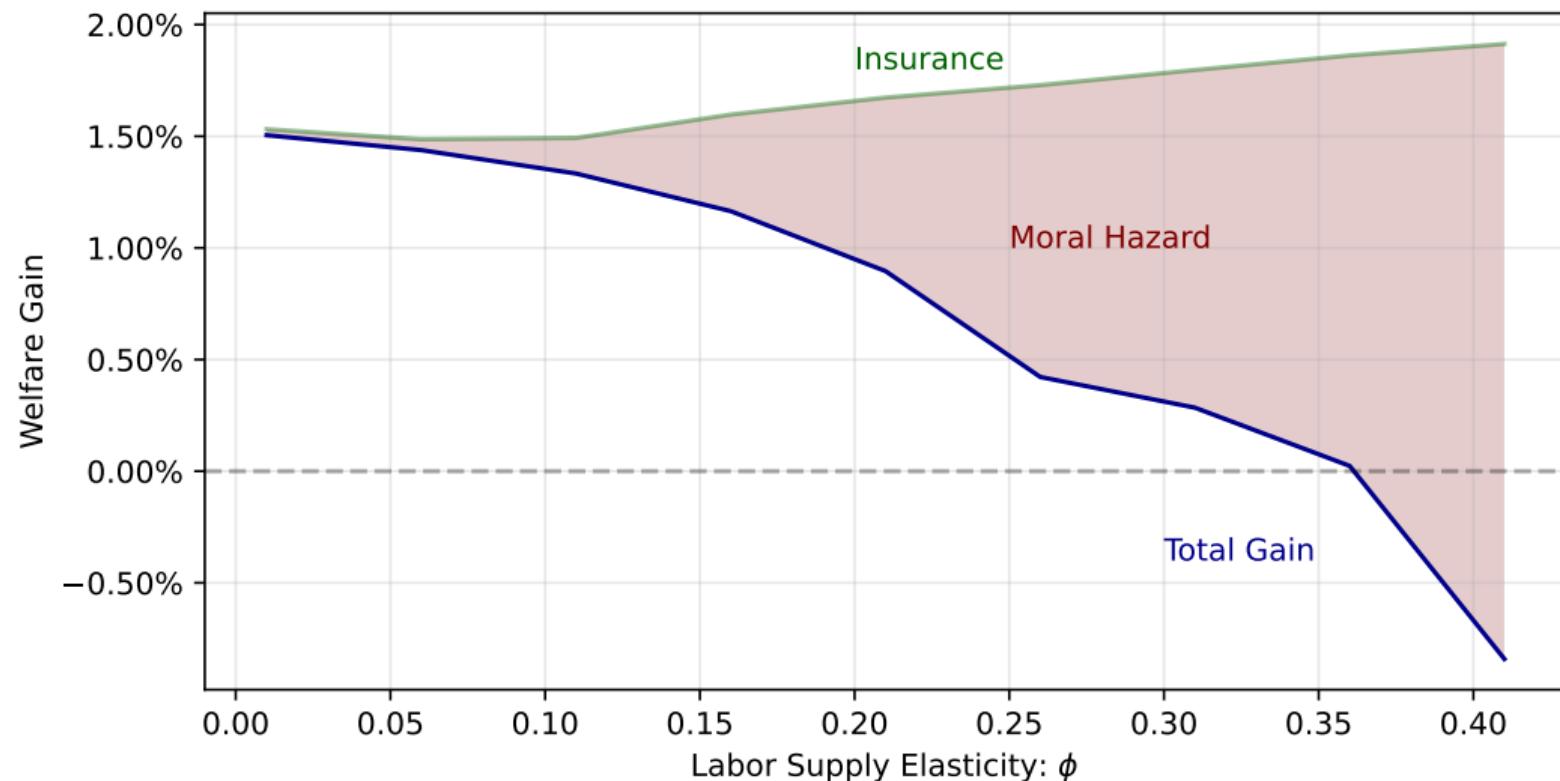


# CONSTRAINED-OPTIMUM = 1.3% INCREASE IN LIFETIME CONSUMPTION



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

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

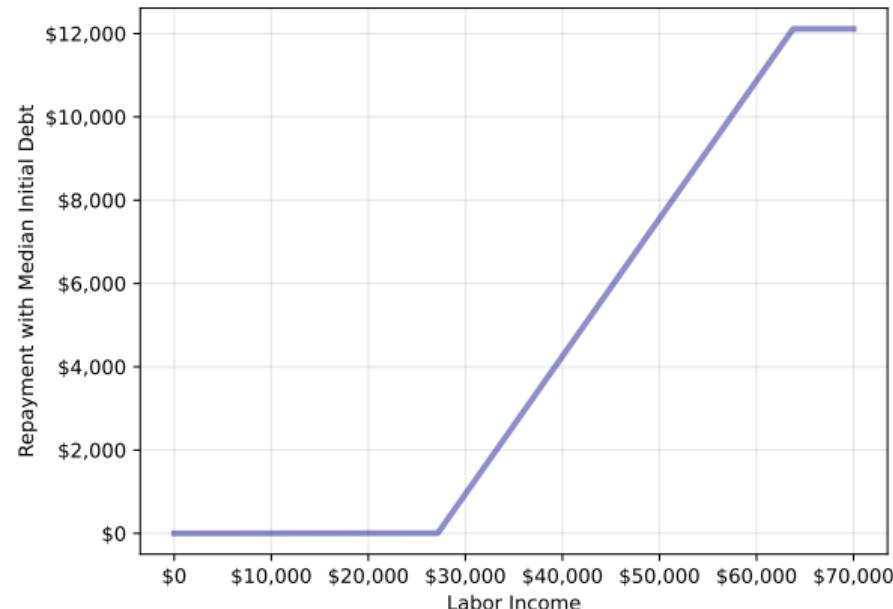
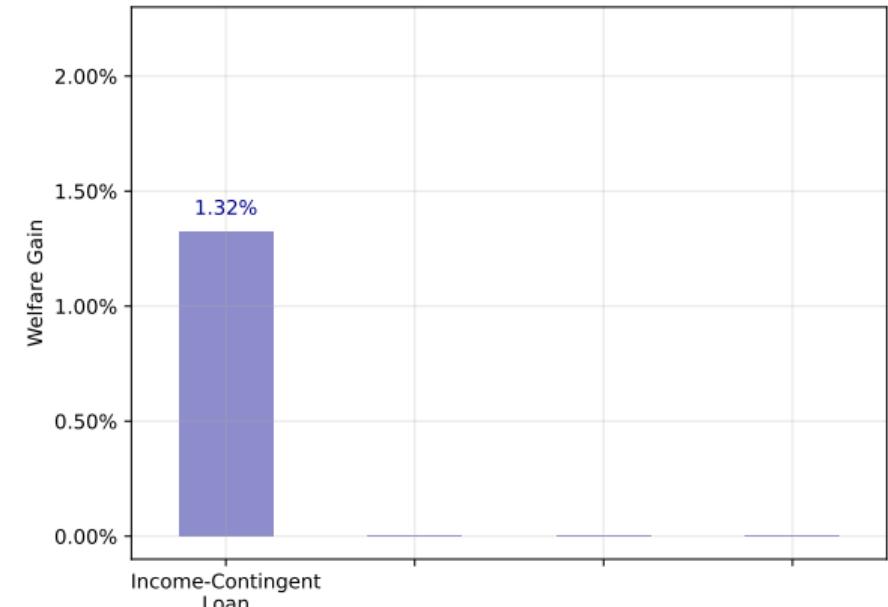


▶ Implied Bunching at  $\phi = 0.37$

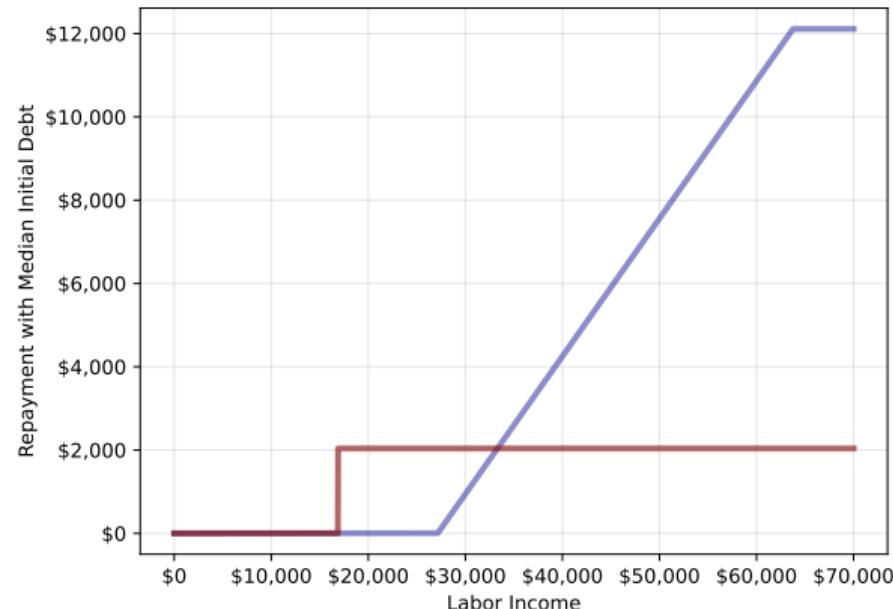
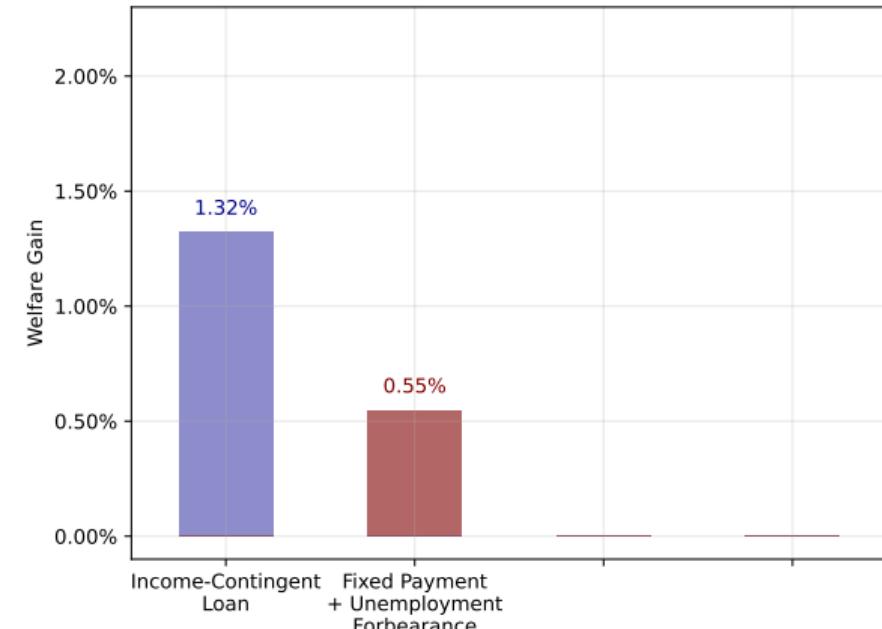
▶ Contracts by  $\phi$

▶ Contracts to Reduce MH

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

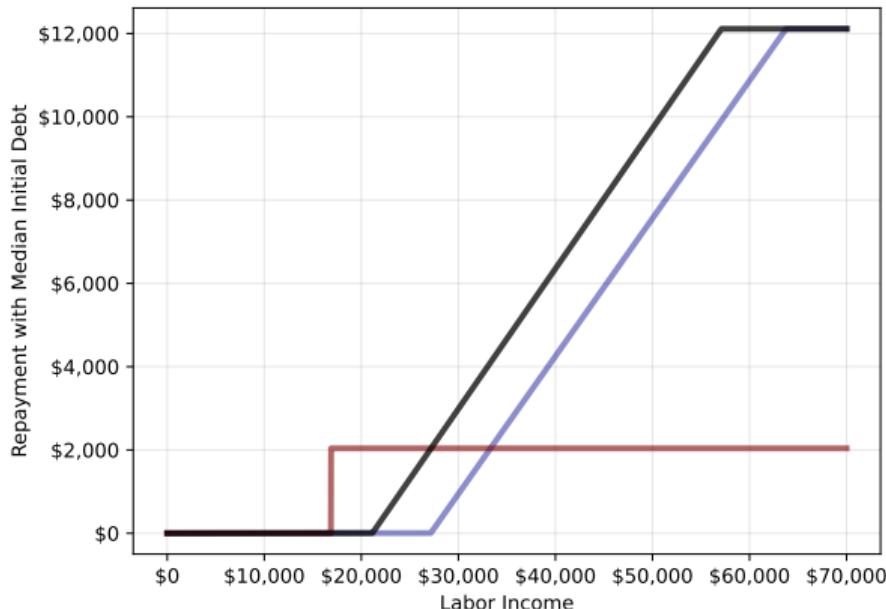
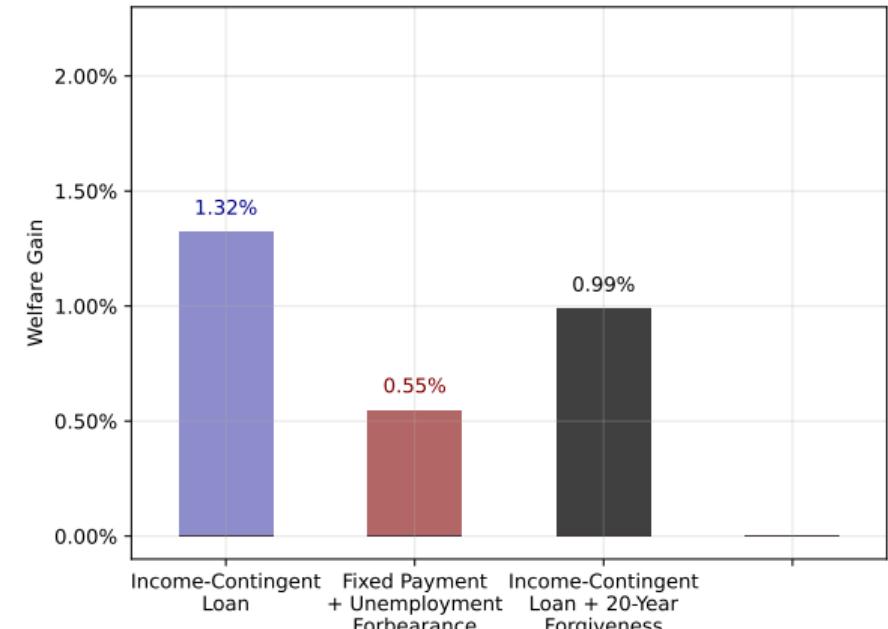


# JUST PROVIDING FORBEARANCE GIVES SMALLER GAINS



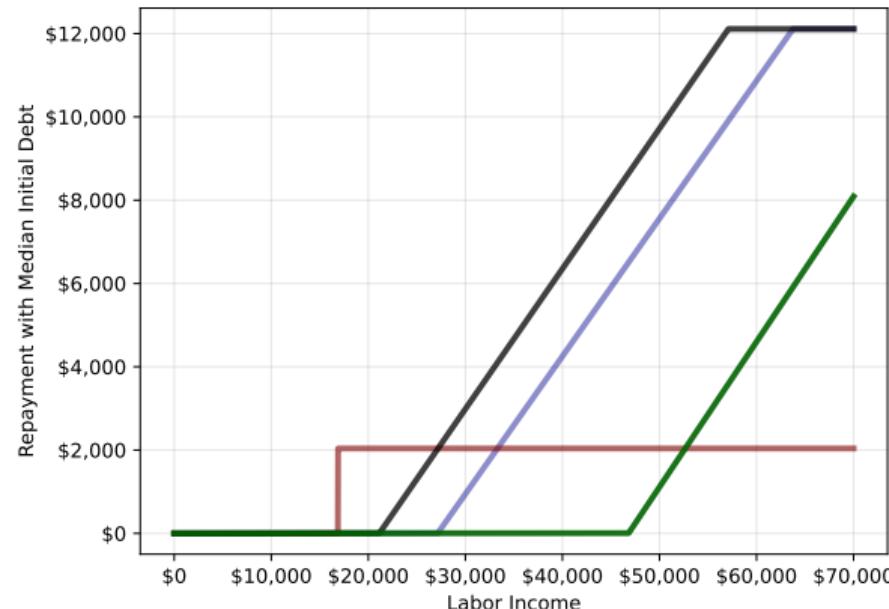
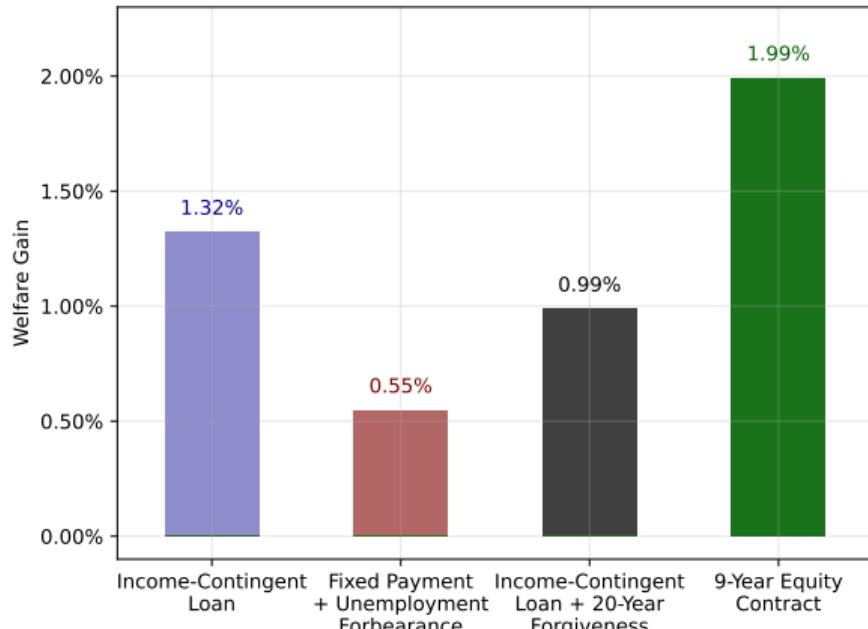
- **Benefit** of income-contingent loan: accelerate payments from high-income

# ADDING FORGIVENESS REDUCES WELFARE GAINS



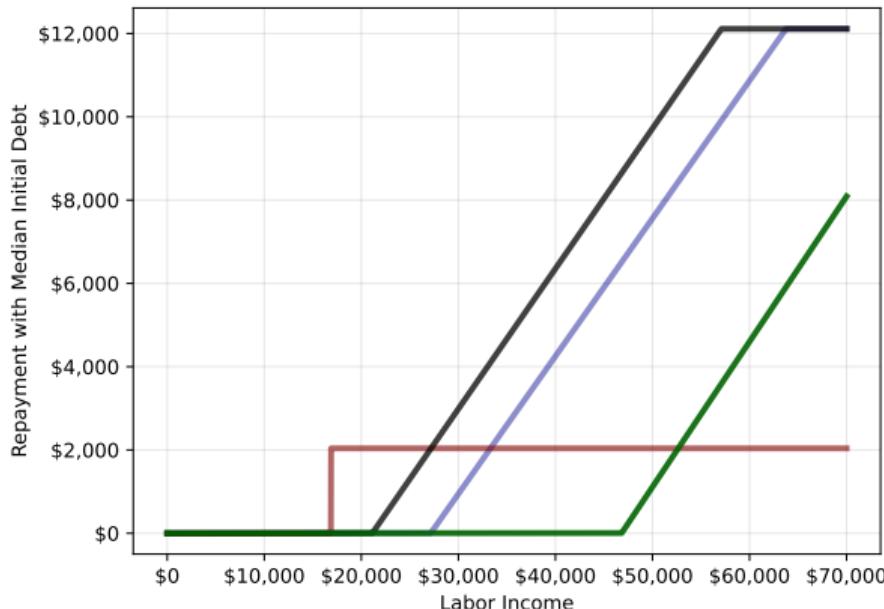
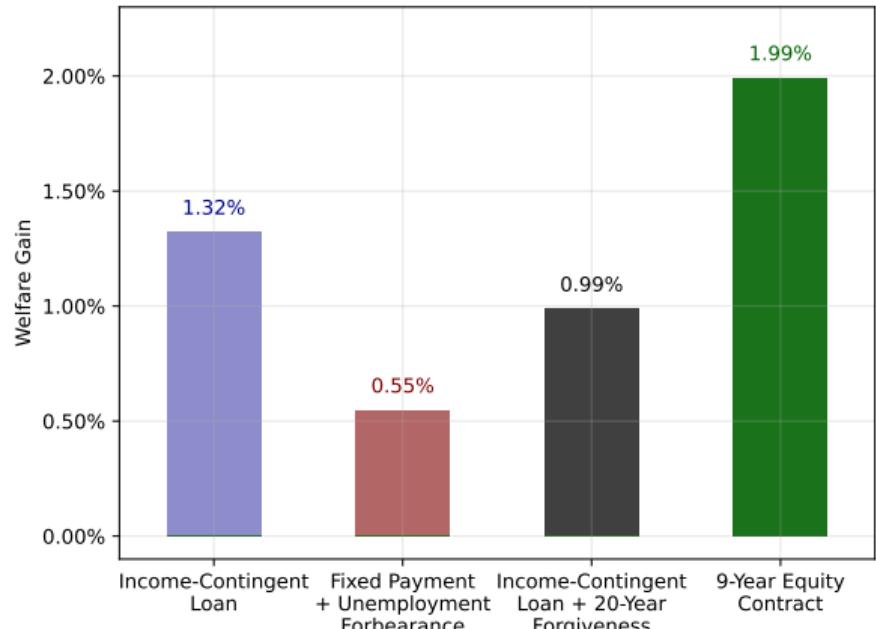
- **Costs** of forgiveness: transfer repayments to young and finite repayment horizon

# EQUITY CONTRACT GIVES LARGER GAINS



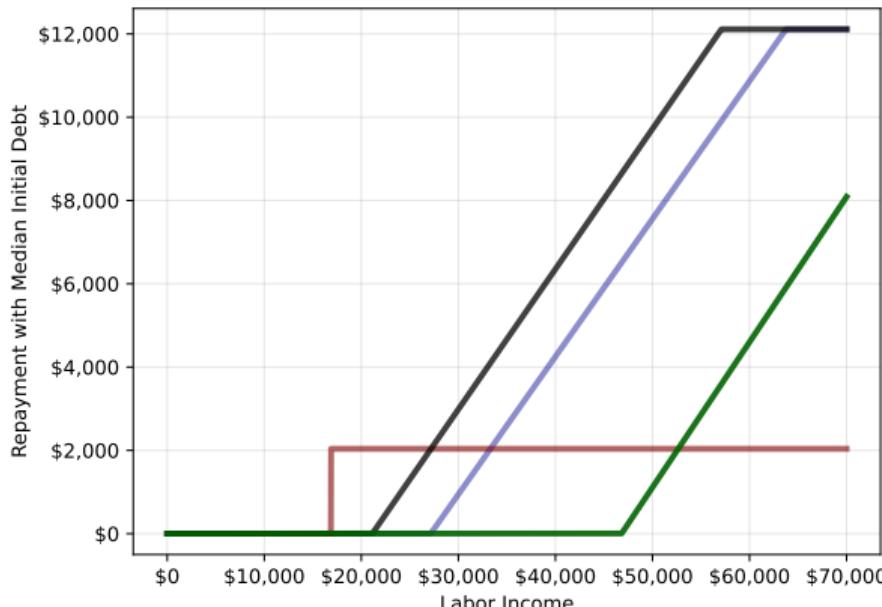
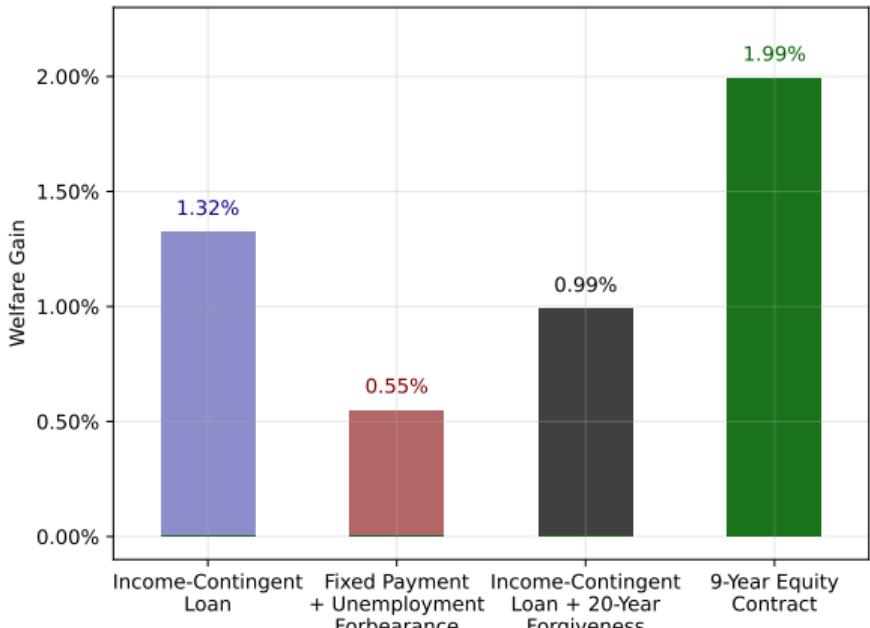
- **Benefit of equity:** uncapped payments from high-income  $\Rightarrow$  70% higher threshold

# EQUITY CONTRACT GIVES LARGER GAINS, BUT MORE DISPERSED



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

# EQUITY CONTRACT GIVES LARGER GAINS, BUT MORE DISPERSED



- **Cost** of equity: more likely to cause **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 and Fiscal Impacts of Income-Contingent Repayment
- 5 Conclusion

# 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

- 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 on education, occupation, and borrowing 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!

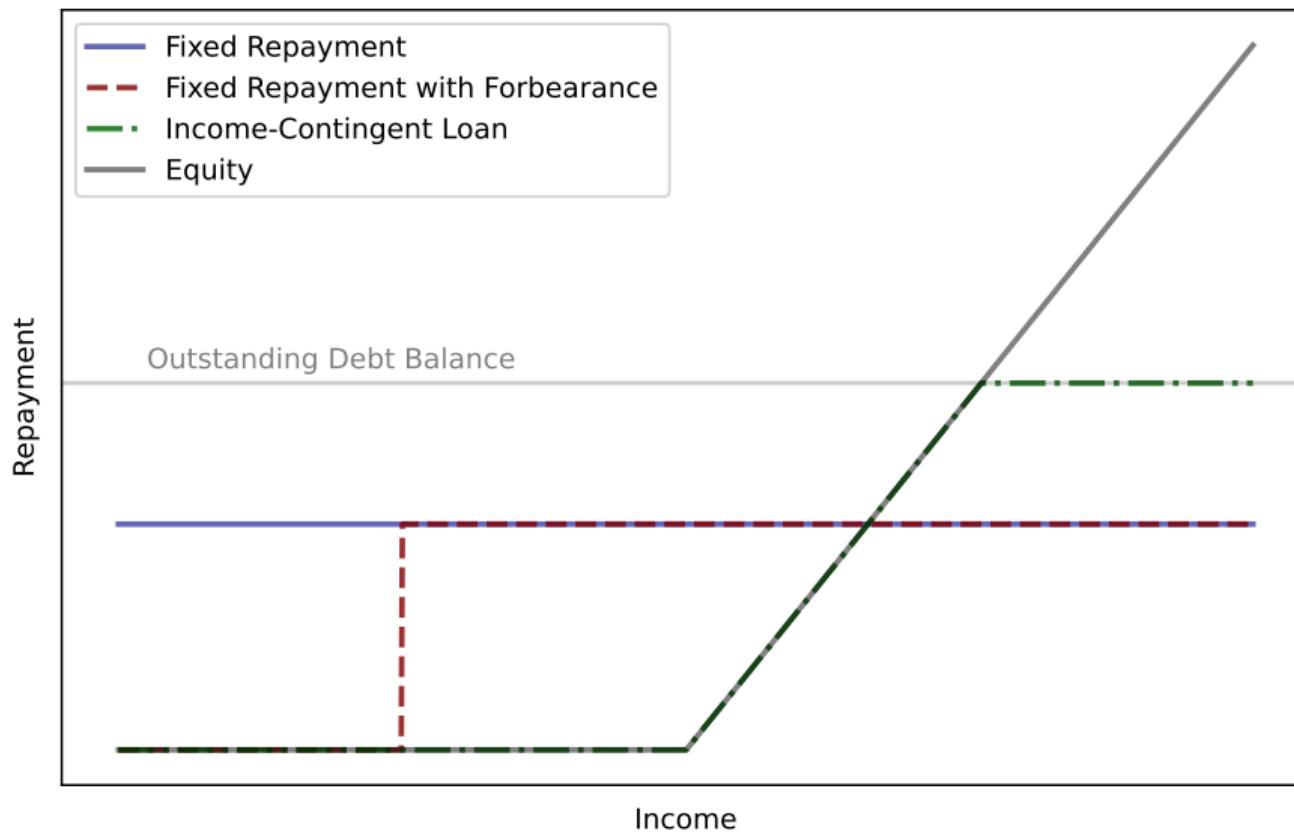
[www.timdesilva.me](http://www.timdesilva.me)

[tdesilva@mit.edu](mailto:tdesilva@mit.edu)

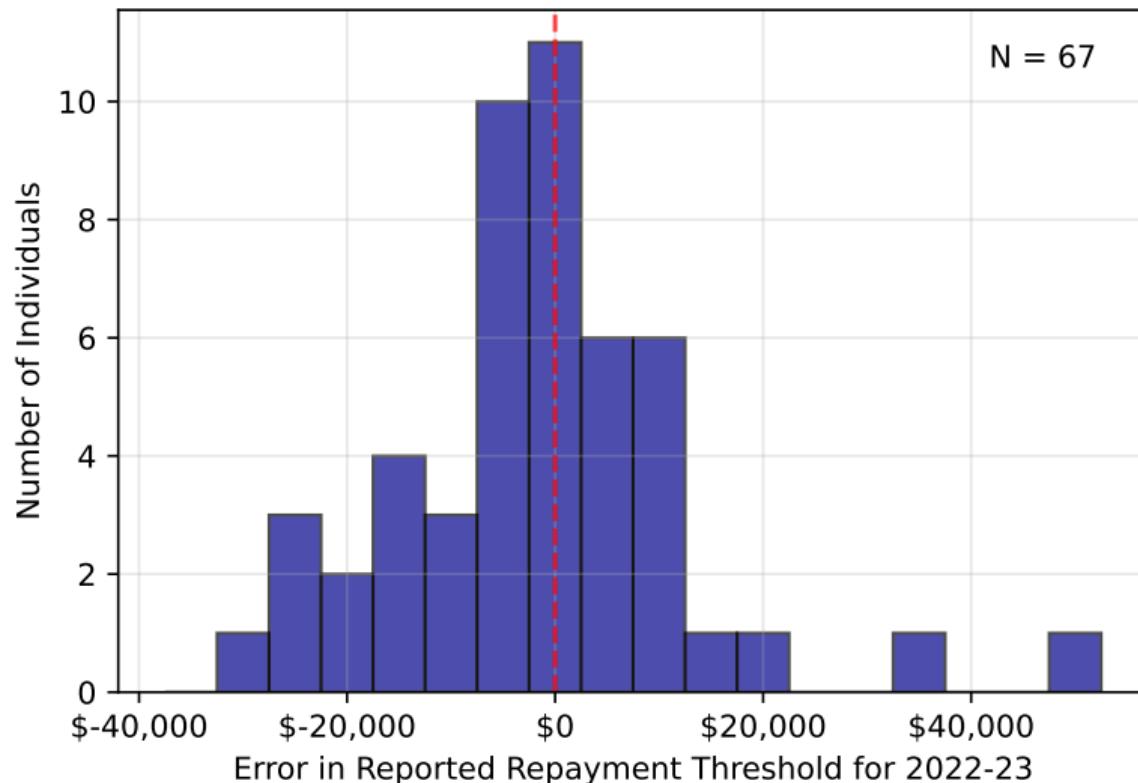
# APPENDIX

# START OF APPENDIX

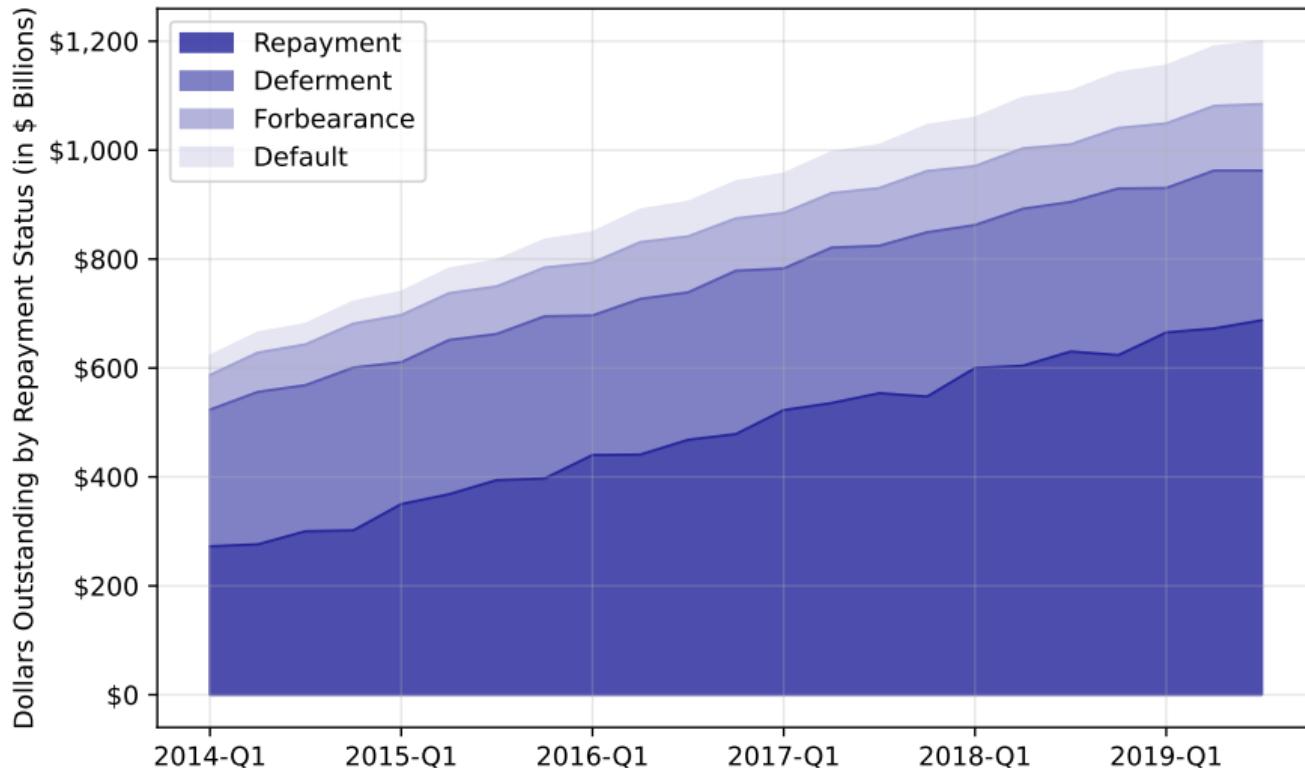
# ILLUSTRATION OF DIFFERENT REPAYMENT CONTRACTS



# 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

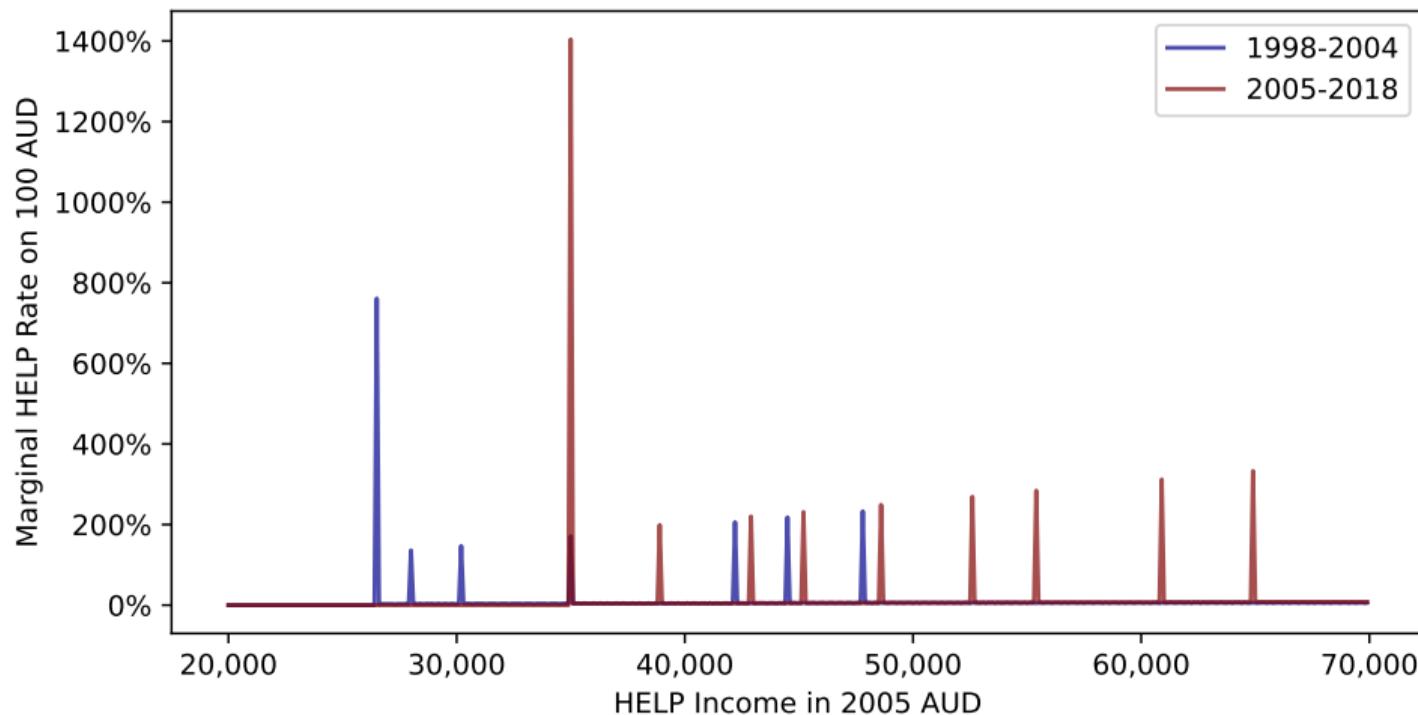
# DIFFERENCES BETWEEN AUSTRALIA AND US: STATISTICS

Feature of Environment	Australia	US
<b>Cost of Higher Education</b>		
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)
<b>Student Population</b>		
% 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%
<b>Income Distribution and Taxes/Transfers</b>		
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](#)

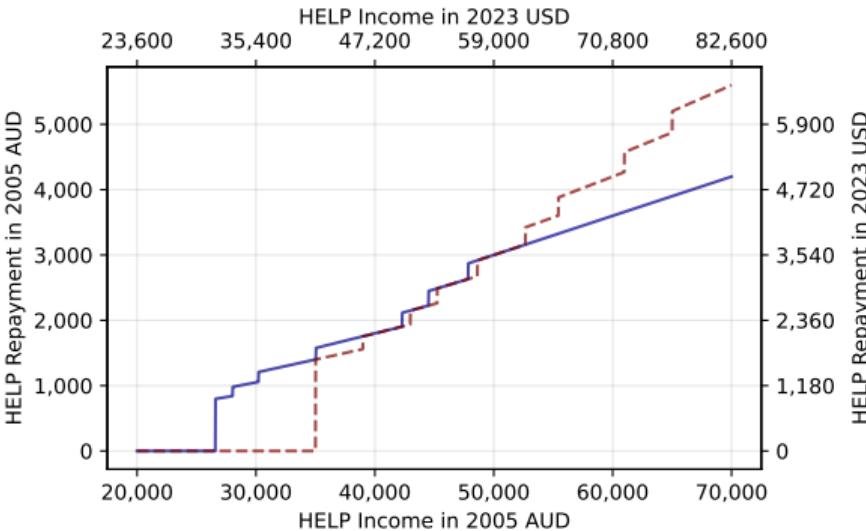
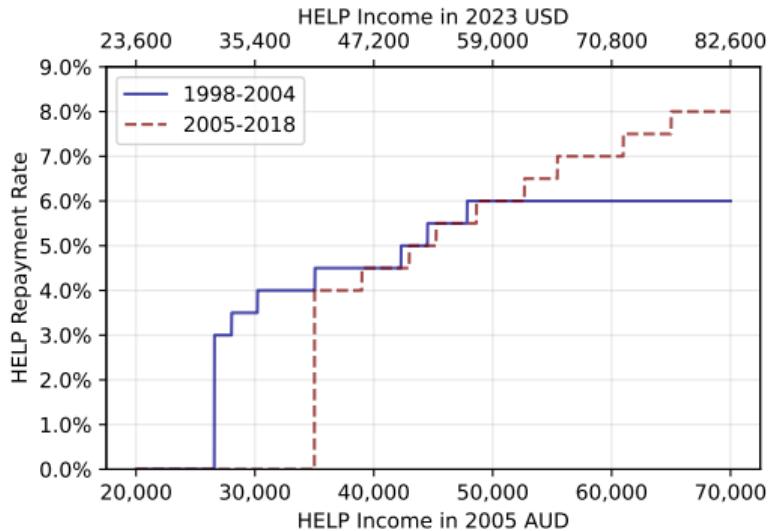
[◀ Back: Differences](#)

# 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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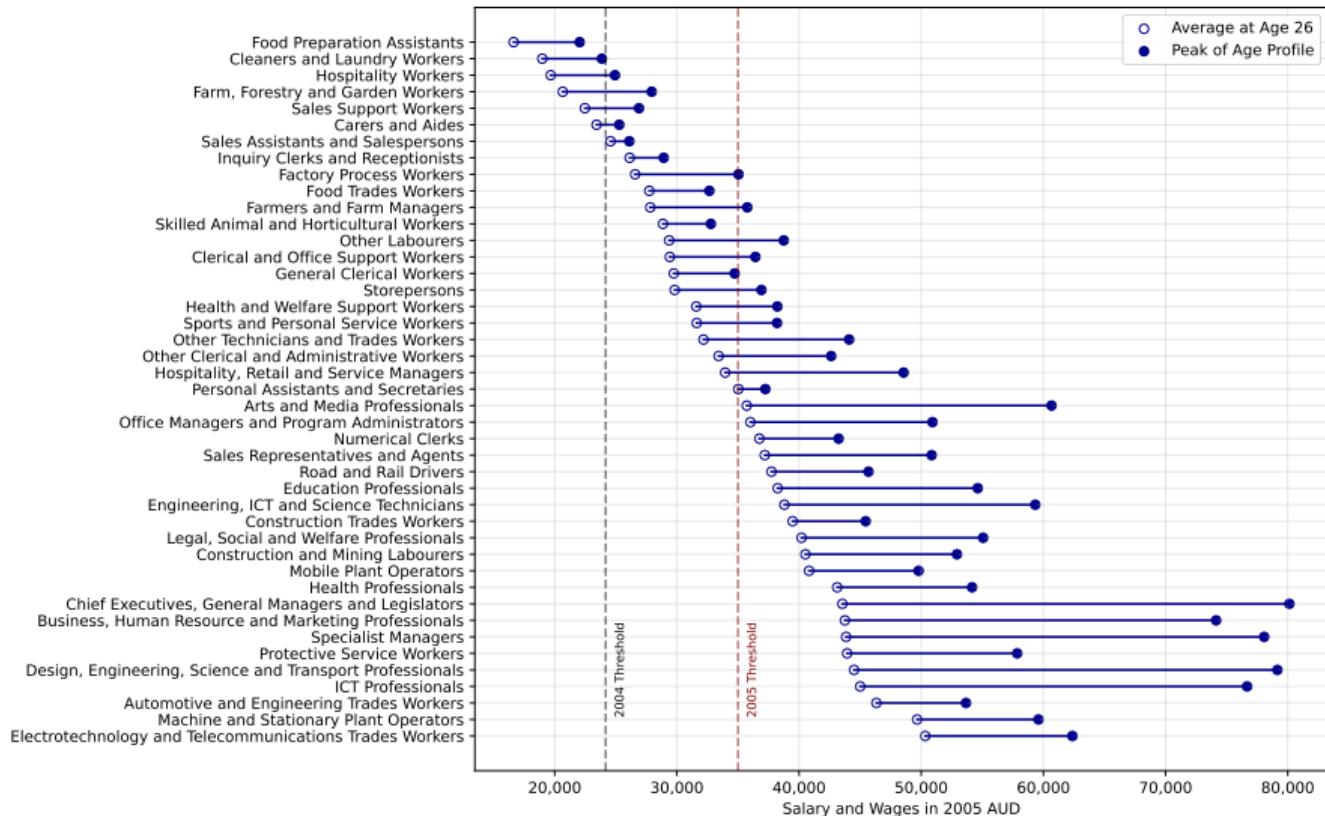


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Australian students owing more than \$9 billion of debts to the federal government should be spared financial heartache under a proposal to lift the income threshold for repayments, the Australian Vice-Chancellors Committee said yesterday.

◀ Back

# OCCUPATION-SPECIFIC INCOME PROFILES RELATIVE TO THRESHOLDS



◀ Back: Policy

◀ Back: Hours

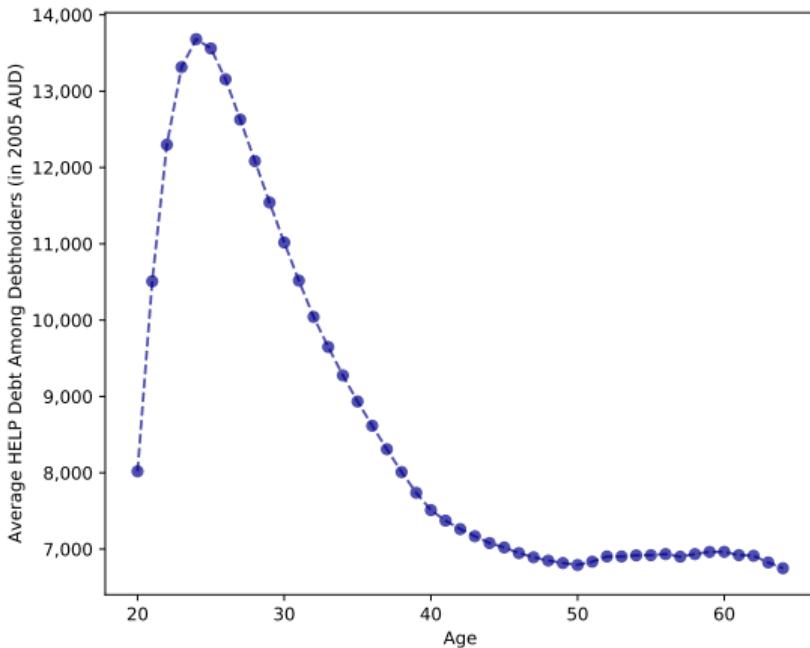
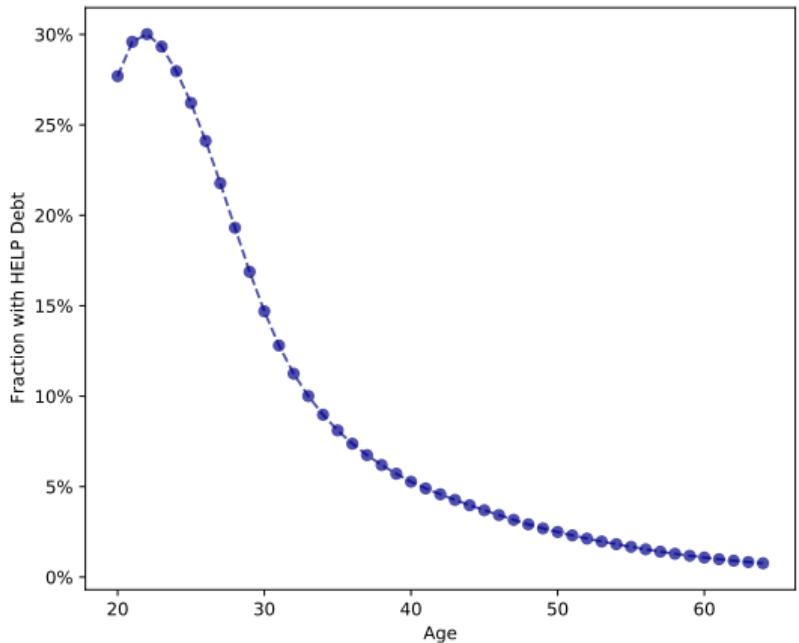
◀ Back: Table

# SUMMARY STATISTICS

	Non-Debtholders (1)	Debtholders (2)
<b>Demographics</b>		
Age	41.1	29.5
Female	0.46	0.60
Wage-Earner	0.85	0.91
<b>Income Totals (in 2005 AUD)</b>		
Taxable Income	37,695	27,796
HELP Income	38,756	28,586
<b>Income Components (in 2005 AUD)</b>		
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
<b>HELP Variables</b>		
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

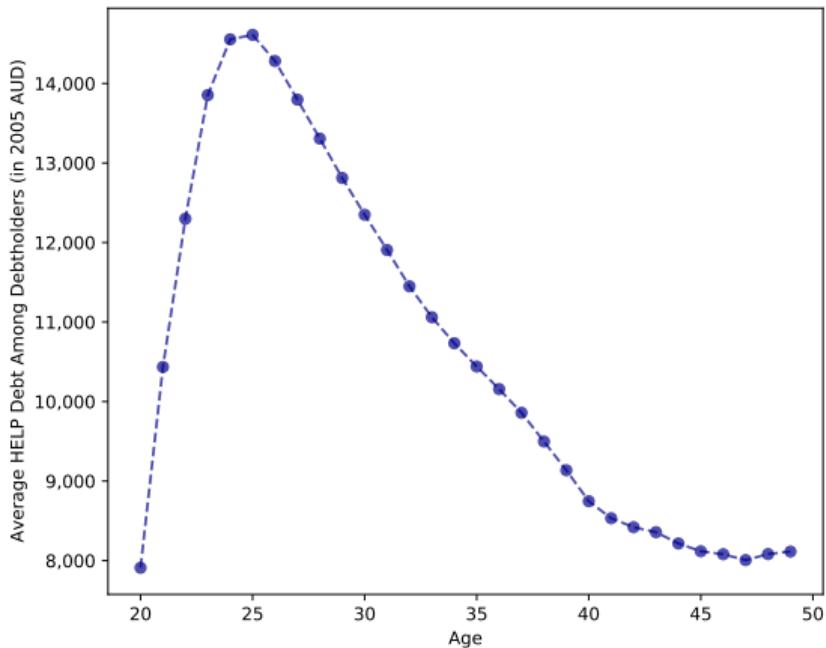
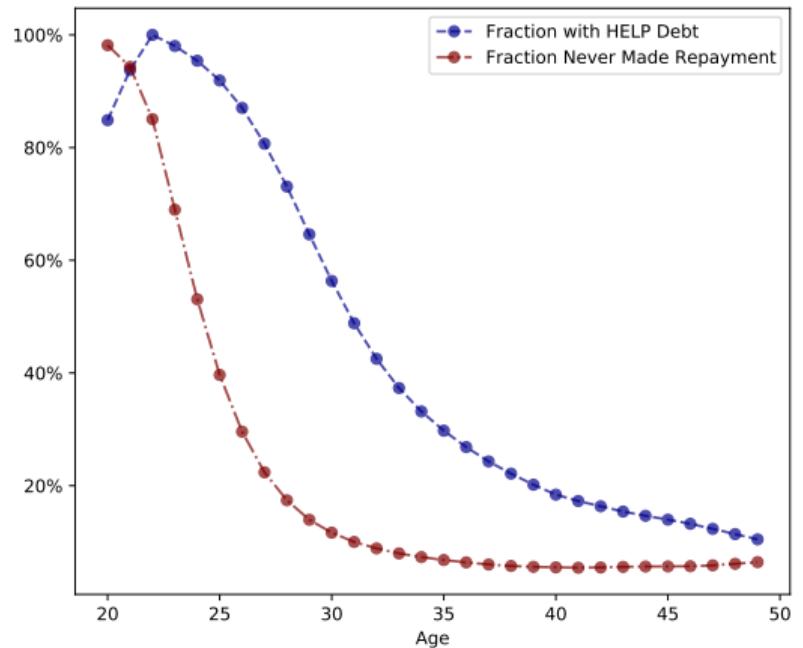
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# DEBT BALANCES BY AGE



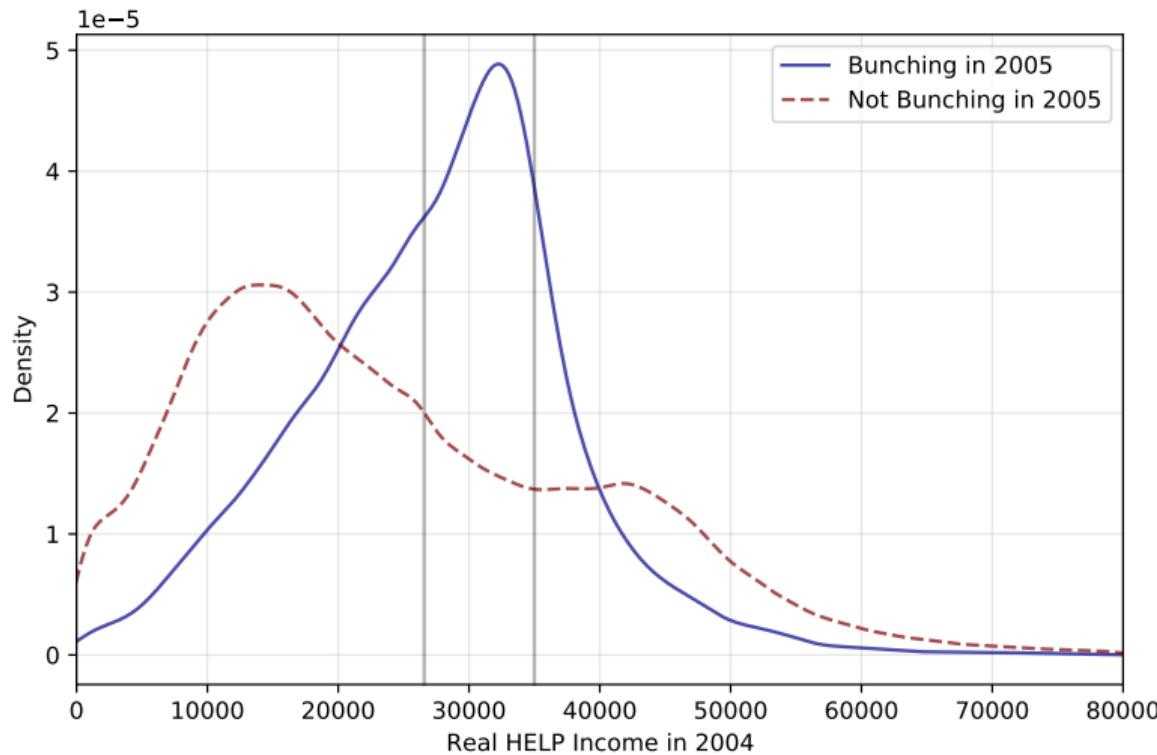
◀ Back

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



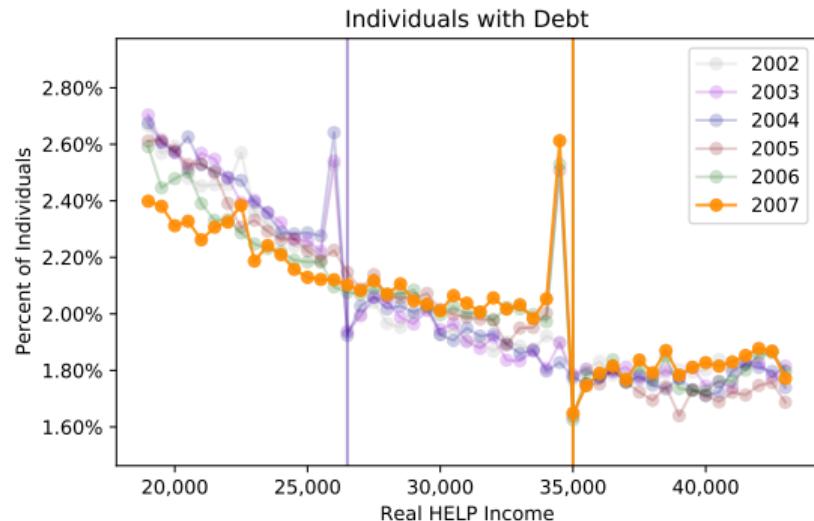
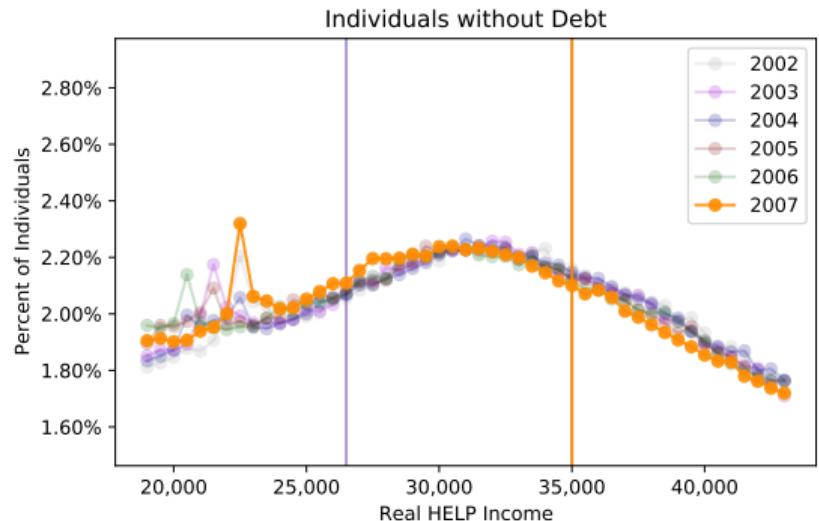
◀ Back

# NEW BUNCHING COMES FROM BETWEEN OLD AND NEW THRESHOLDS



◀ Back

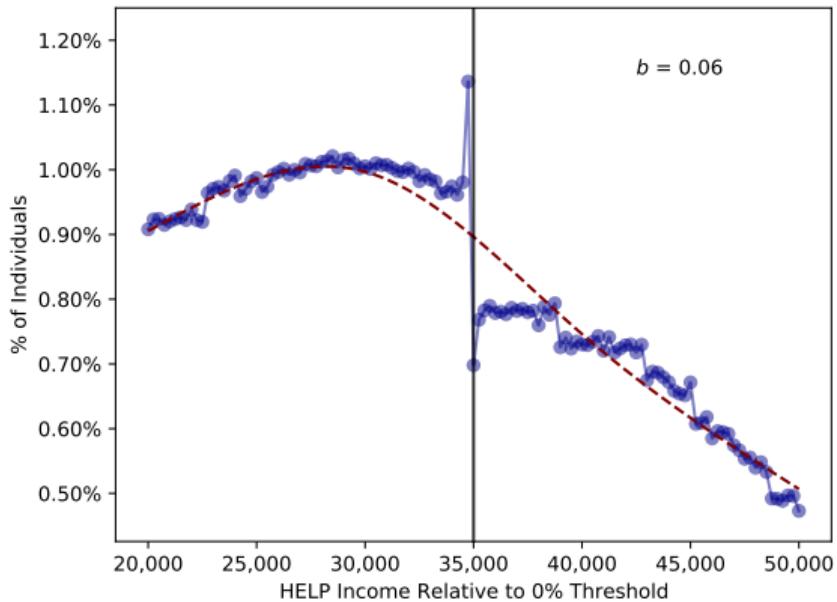
# No BUNCHING AT REPAYMENT THRESHOLD FOR NON-DEBTHOLDERS



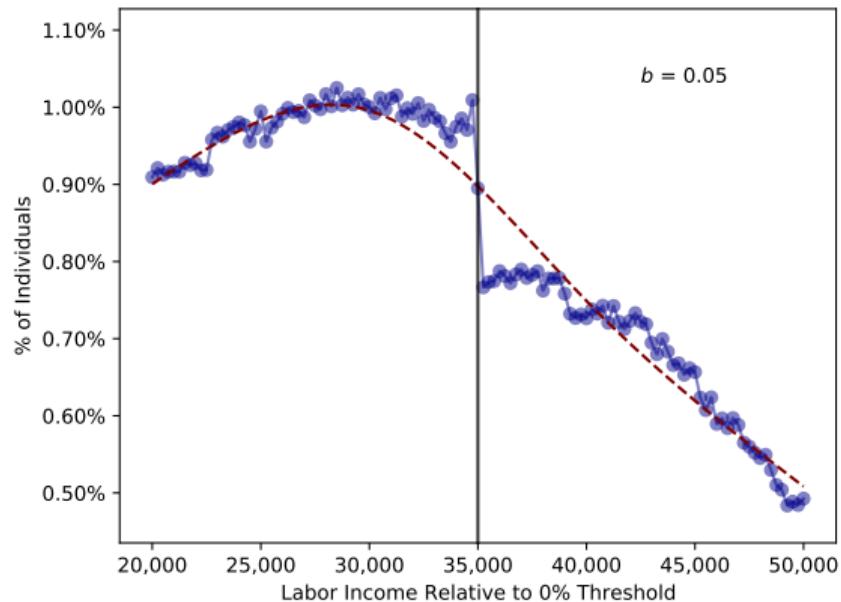
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# BUNCHING IN LABOR INCOME = 83% OF BUNCHING IN HELP INCOME

## HELP Income

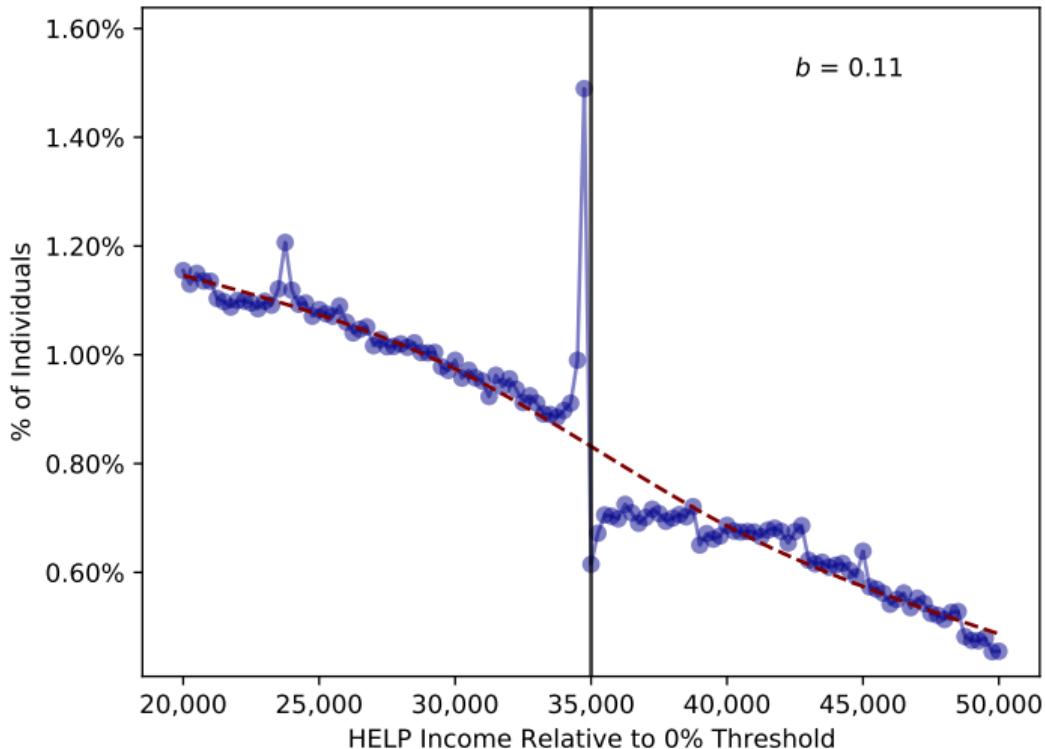


## Labor Income



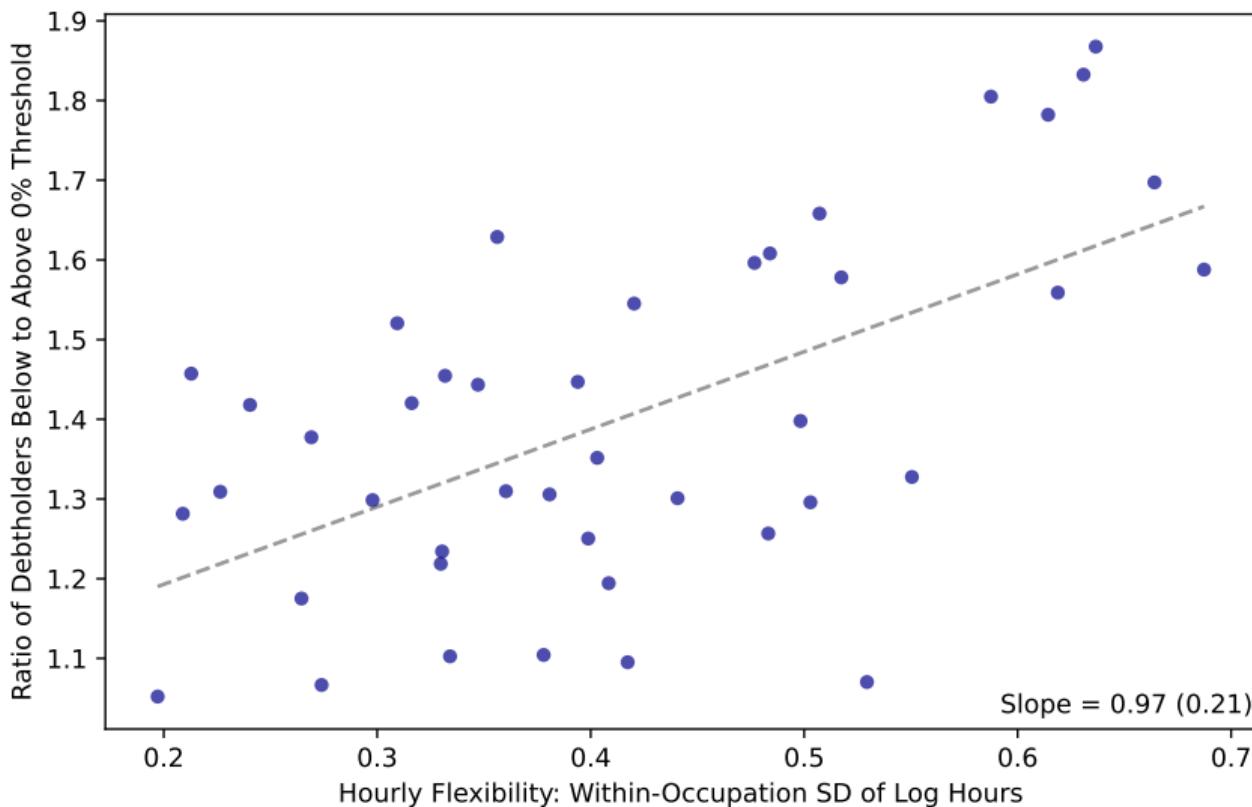
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# BUNCHING AT THRESHOLD IS LARGER THAN AT TAX KINK: 2016



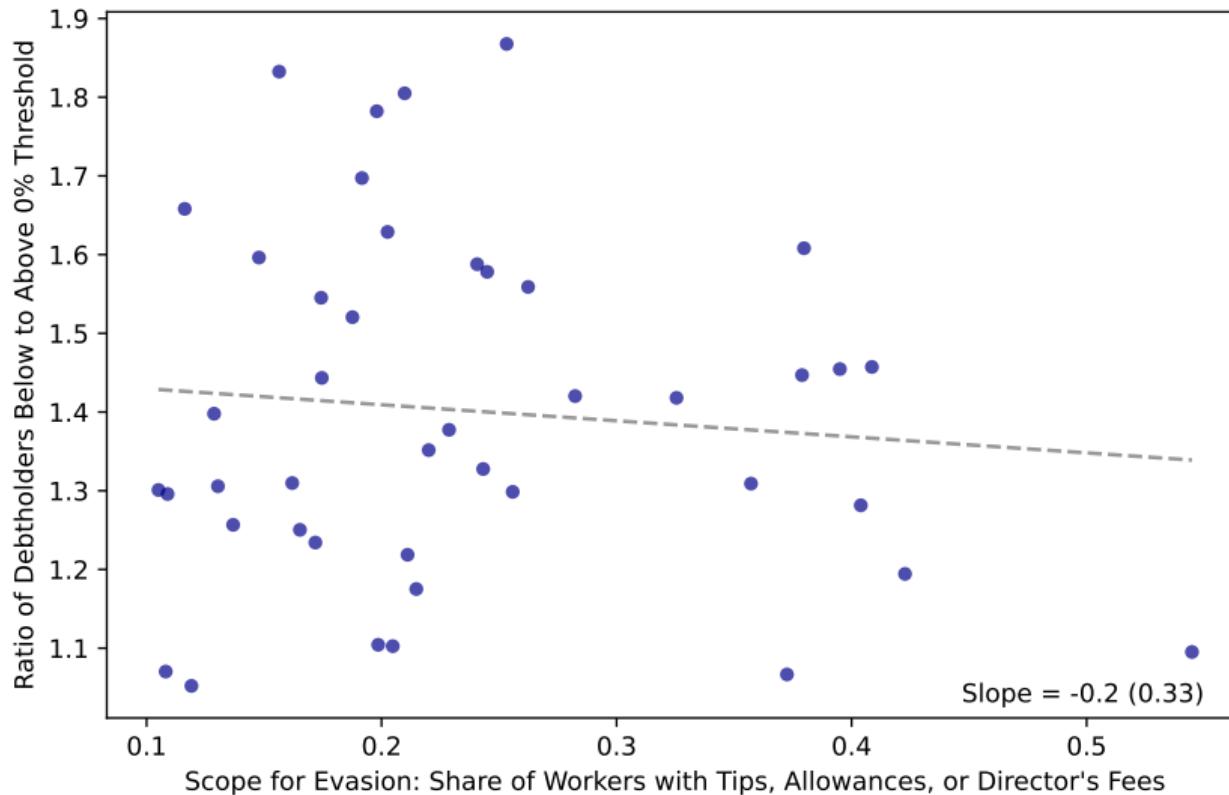
◀ Back

# ALTERNATIVE MEASURE OF HOURLY FLEXIBILITY



◀ Back

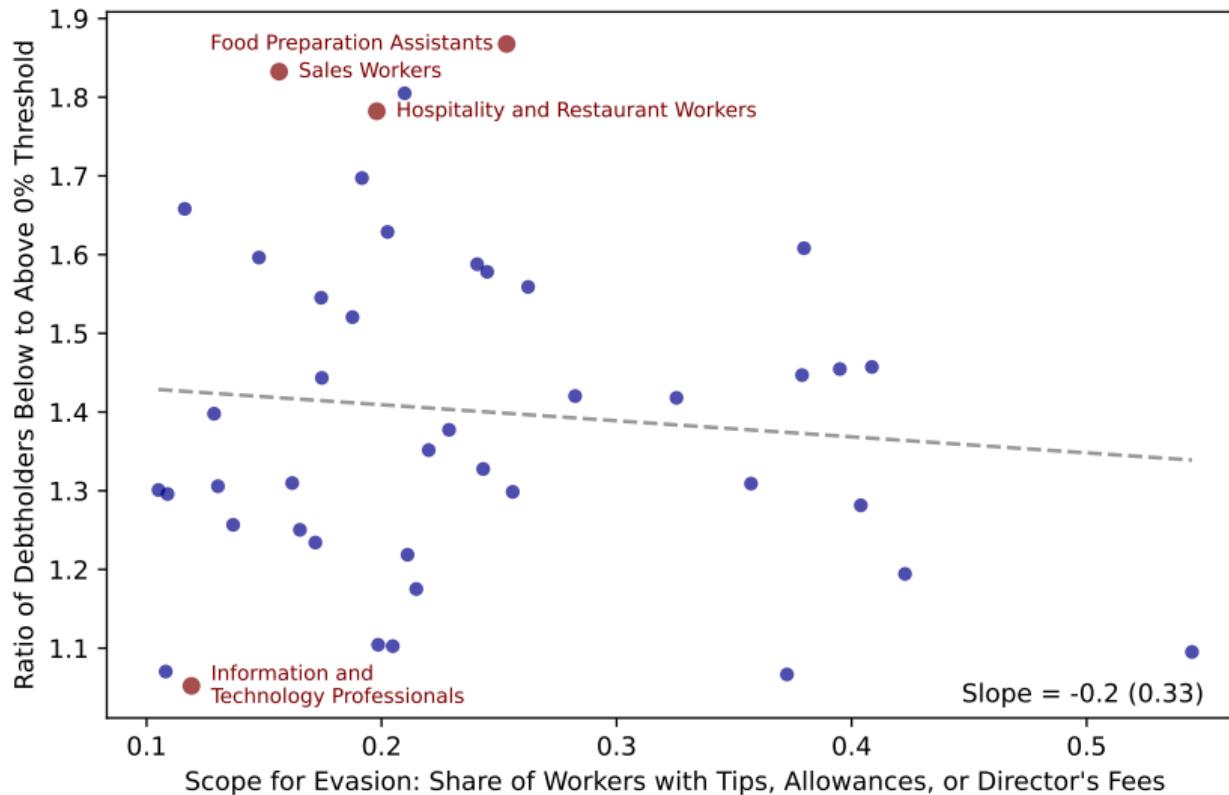
# BUNCHING UNCORRELATED WITH MEASURE OF EVASION



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

◀ Back

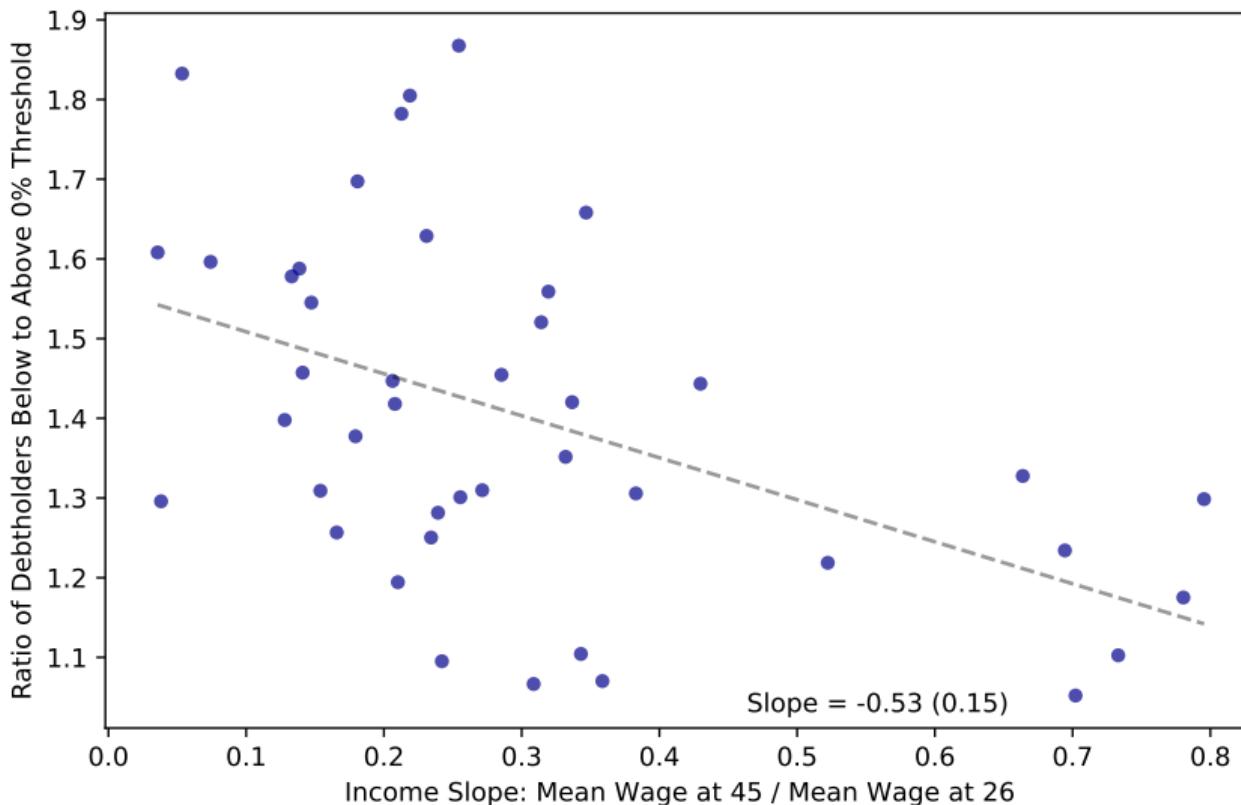
# BUNCHING UNCORRELATED WITH MEASURE OF EVASION



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

◀ Back

# BUNCHING DECREASES WITH EXPECTED WAGE GROWTH



▶ Table

◀ Back: Hours

◀ Back: Summary

# 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> <sup>2</sup>	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: Summary

## COMPUTATION OF BUNCHING STATISTIC

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

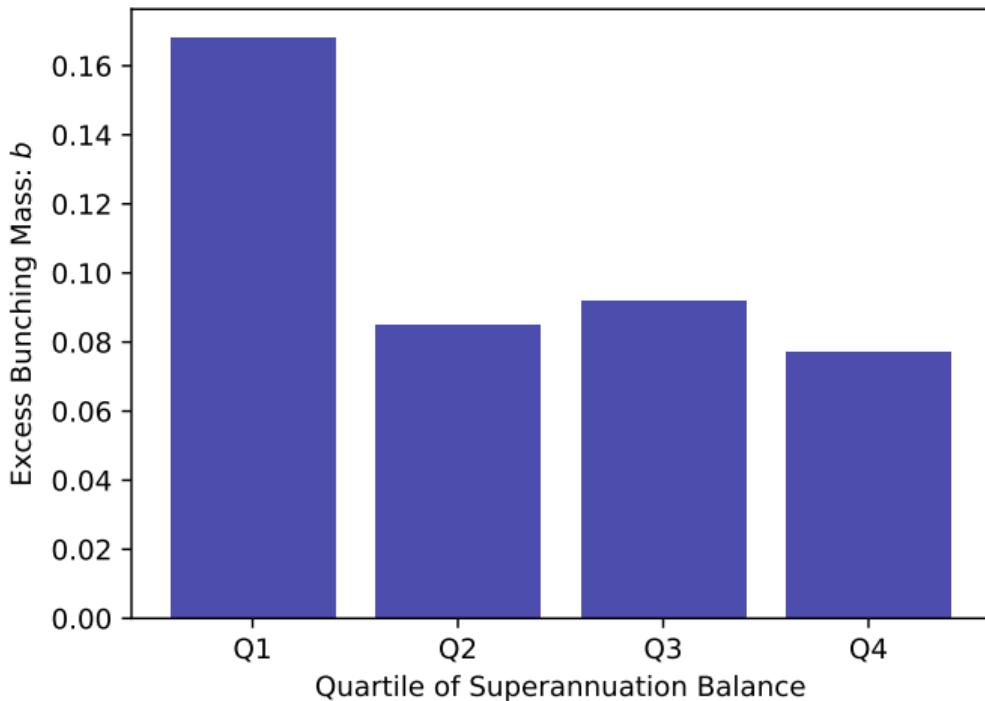
- Fit 5-piece spline leaving out  $[\$32,500, \$35,000 + X]$   $\Rightarrow$  **counterfactual density**
- Iterate and choose  $X$  so that counterfactual density integrates to 1
- 

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

- $b = 0.1 \Rightarrow$  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**

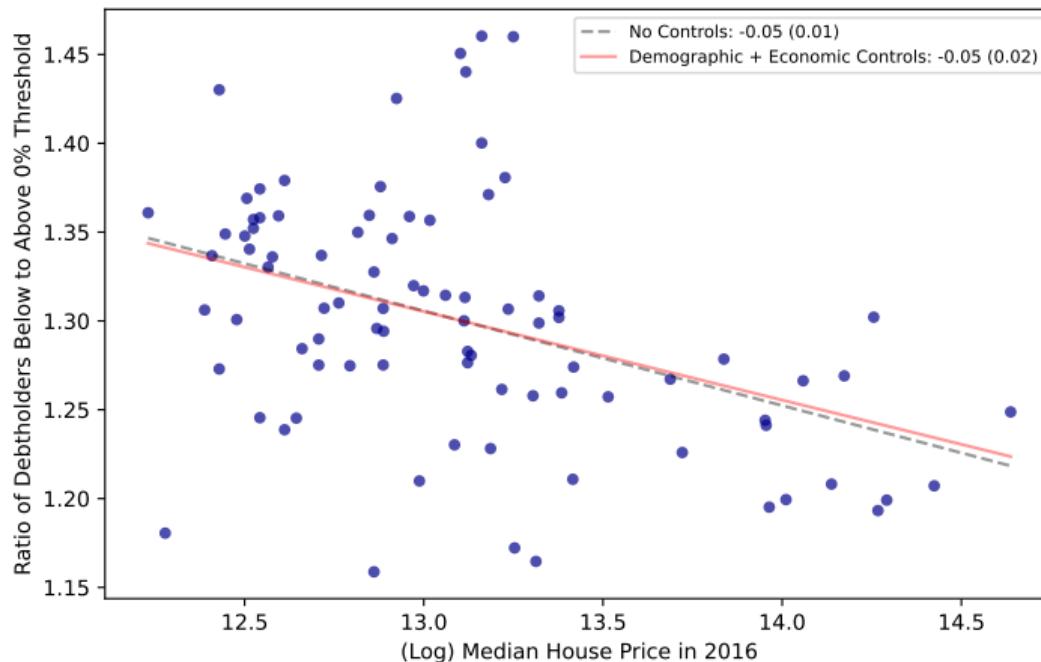
◀ Back

# BUNCHING HETEROGENEITY BY SUPER WEALTH: AGES 20-29



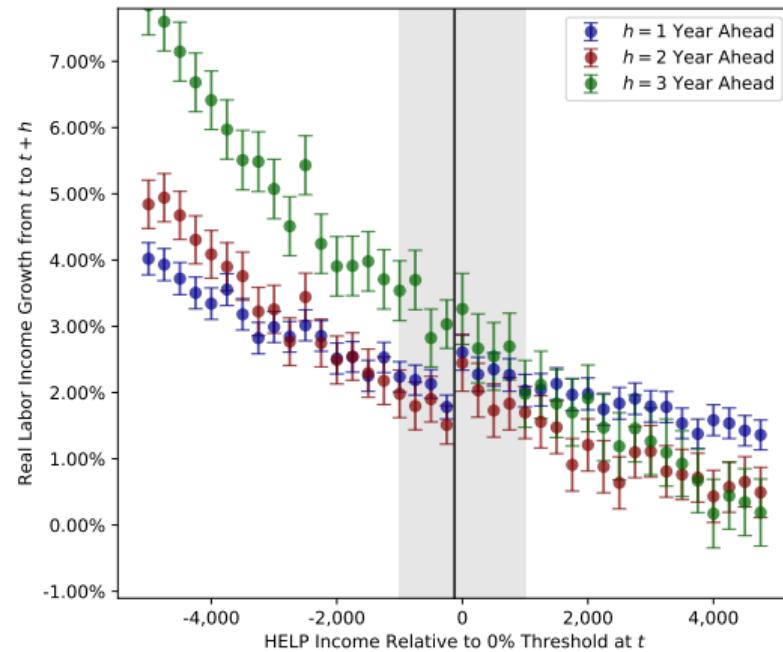
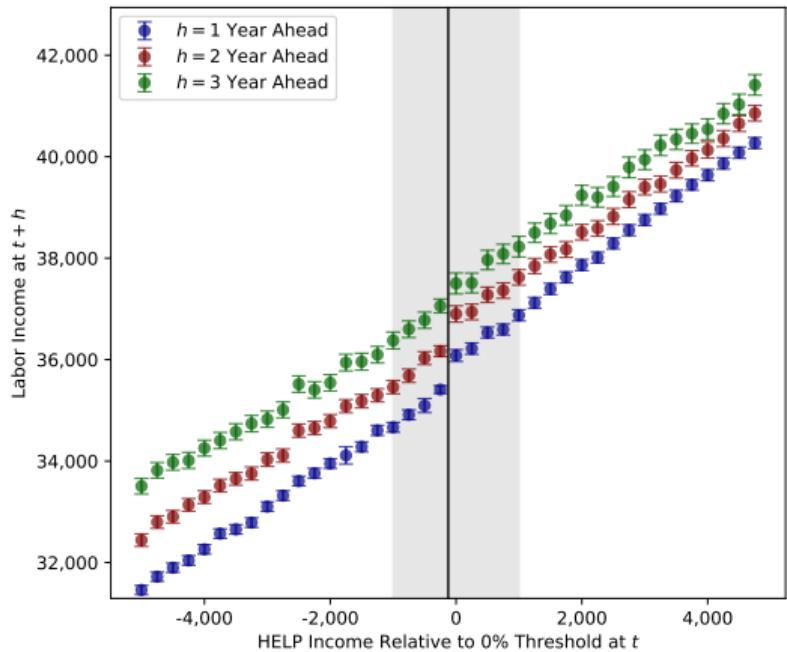
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# LESS BUNCHING IN REGIONS WITH MORE HOUSING WEALTH



◀ Back

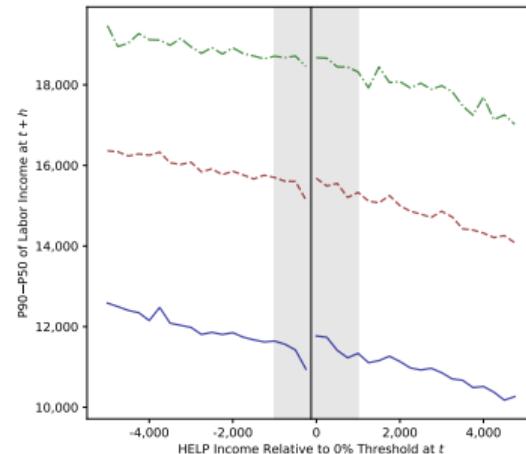
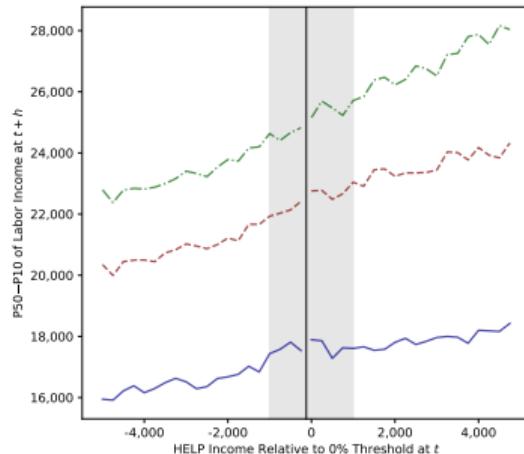
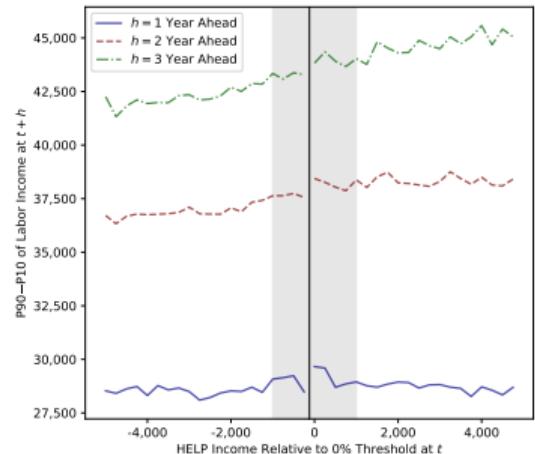
# LIMITED EVIDENCE OF DYNAMIC COST TO BUNCHING



▶ Distribution

◀ Back

# LITTLE DIFFERENCE IN DISTRIBUTION OF FUTURE INCOME



◀ Back

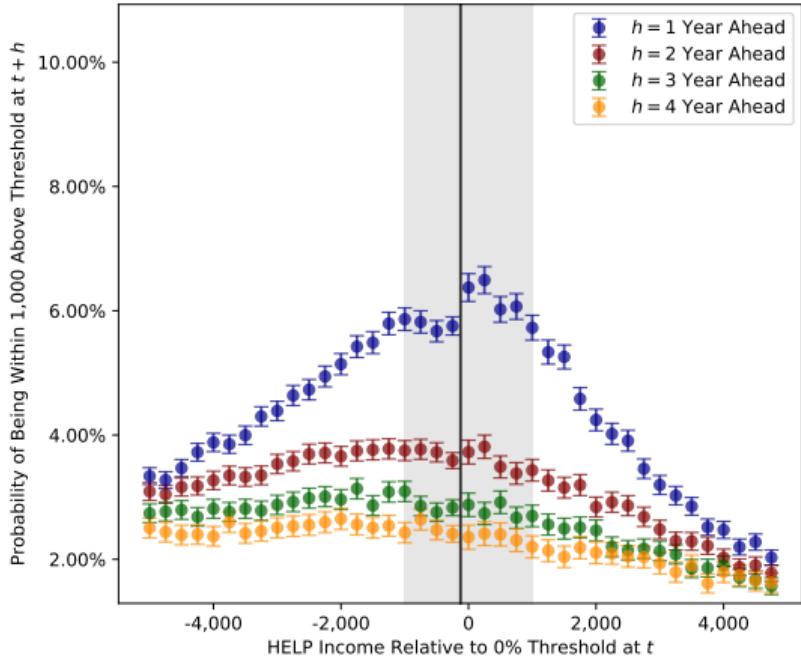
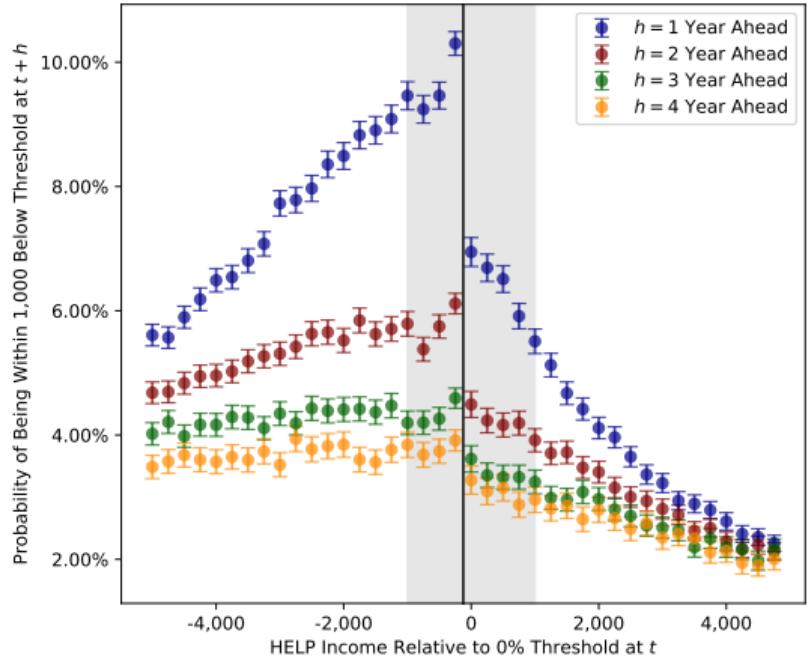
# ADDITIONAL EMPIRICAL RESULTS

- 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

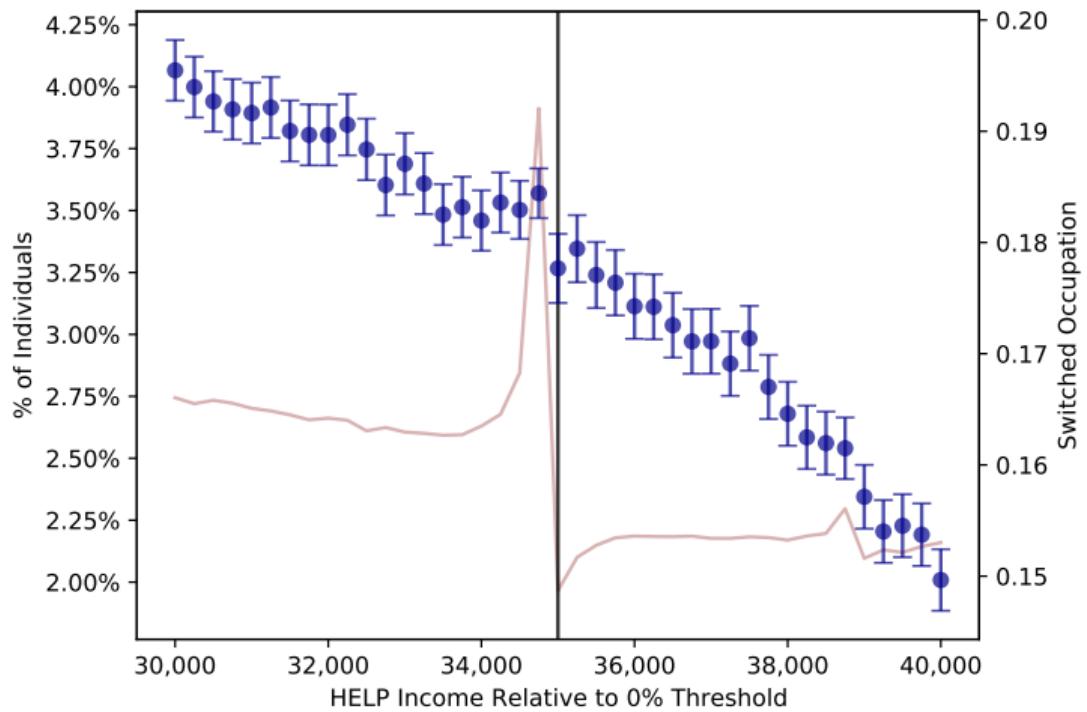
 Back: Summary

# PERSISTENCE OF BUNCHING LASTS AROUND THREE YEARS



◀ Back

# No Discontinuity in the Probability of Switching Occupations



◀ Back

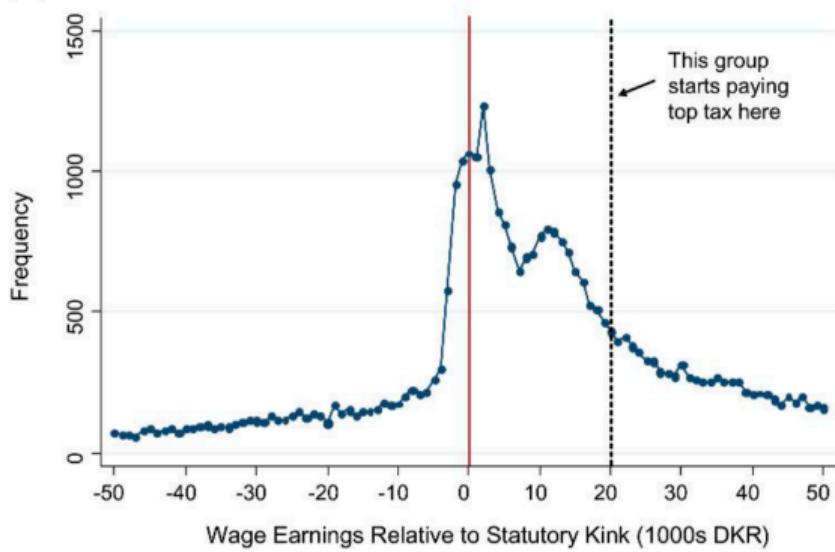
## DEMOGRAPHIC HETEROGENEITY IN BUNCHING

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
<b>Full Sample</b>	<b>0.084</b>

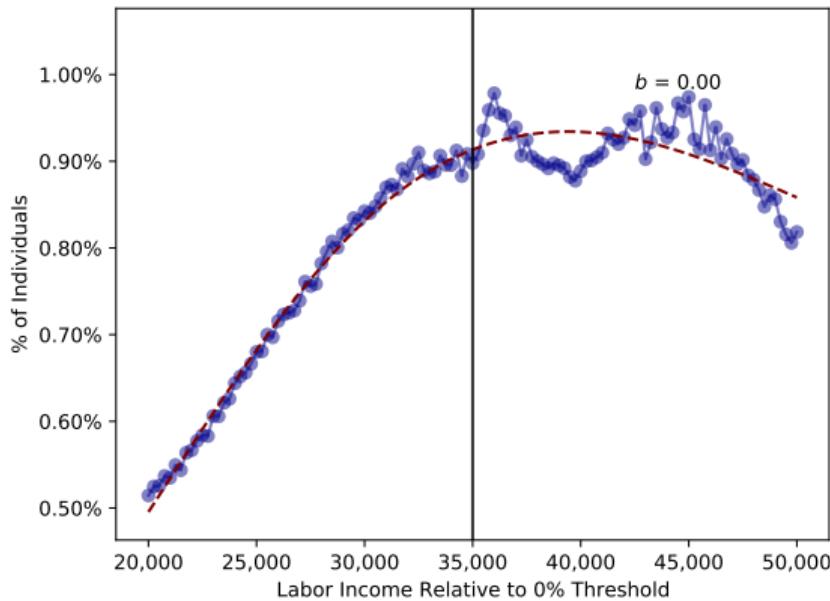
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# CHETTY ET AL. (2011) TEST OF FIRM RESPONSES

## Chetty et al: Teacher Wages



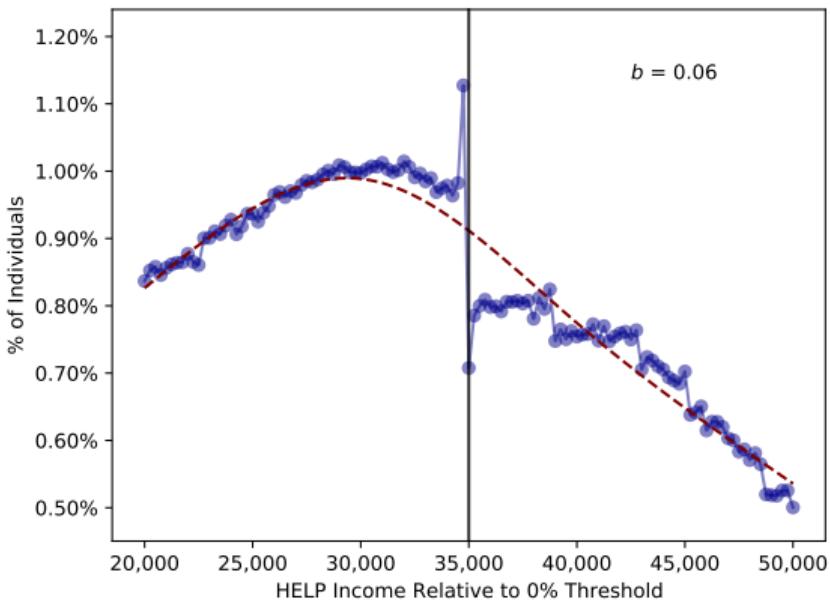
## Borrower Labor Income



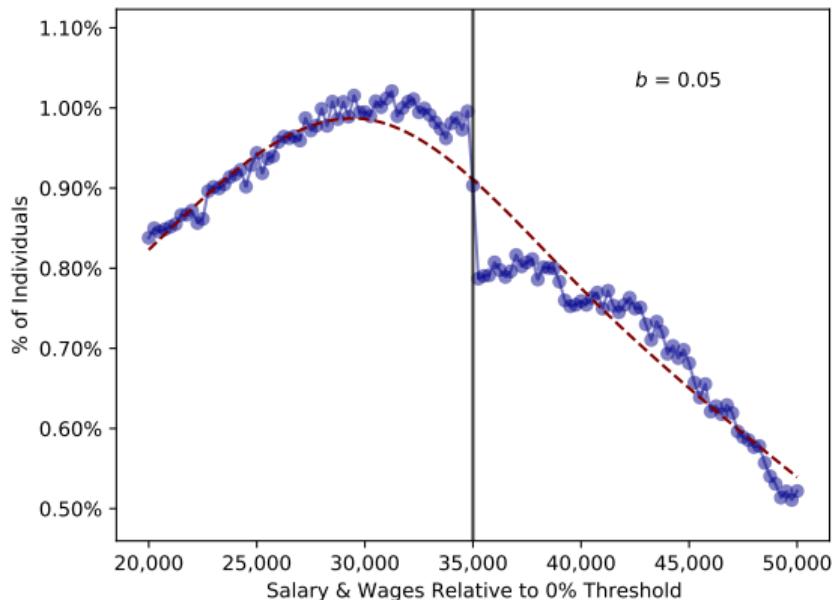
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# BUNCHING IN DISTRIBUTION OF SALARY AND WAGES

## HELP Income



## Salary and Wages



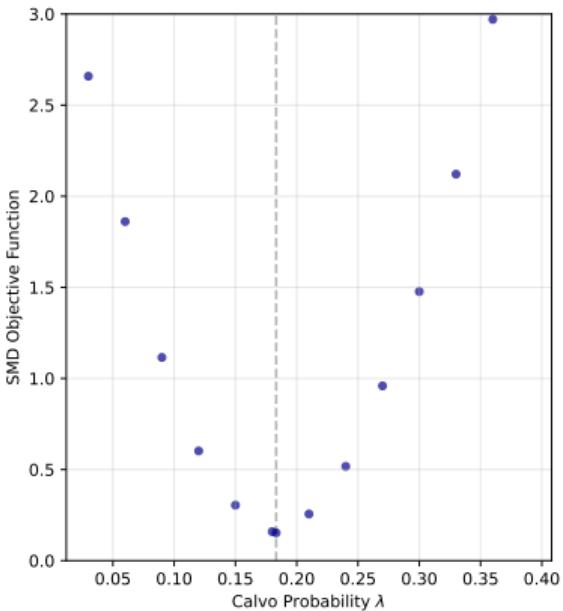
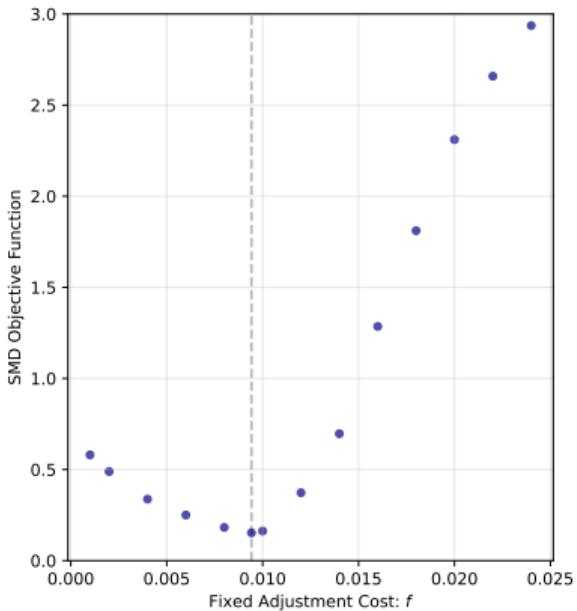
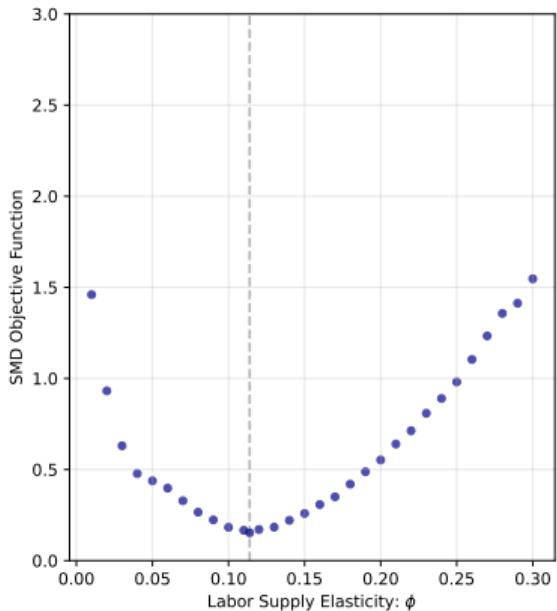
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## ELASTICITY OF MOMENTS WITH RESPECT TO PARAMETERS

	$\phi$	$f$	$\lambda$
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



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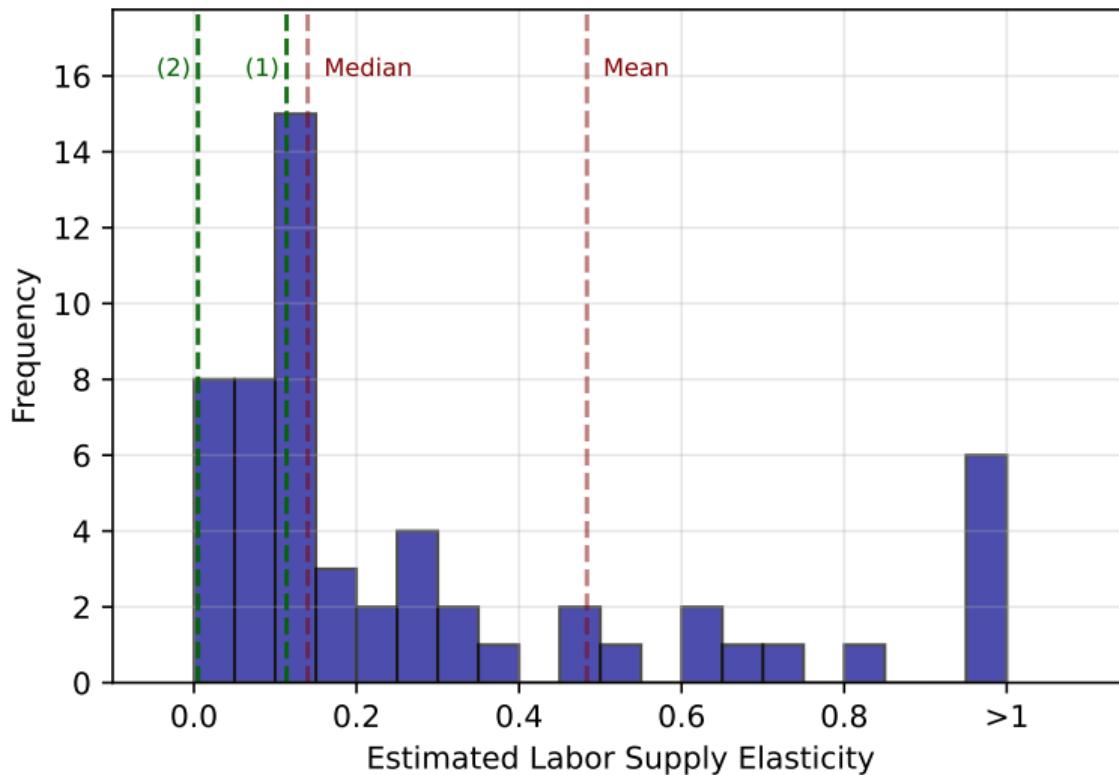
## SECOND-STAGE SIMULATED MINIMUM DISTANCE: OTHER MOMENTS

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

- 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  $\Rightarrow$   $\beta$
- Average labor supply  $\Rightarrow$   $\kappa$

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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
  - $\ell_t$  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

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# FULL ESTIMATION RESULTS

Parameter		Estimation						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Labor supply elasticity	$\phi$	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	$\lambda$	0.183 (.003)	1 . .	1 . .	0.147 (.002)	0.346 (.009)	0.191 (.003)	0.266 (.005)
Scaling parameter	$\kappa$	0.560 (.007)	0.030 (.003)	0.059 (.014)	0.510 (.012)	1.242 (.116)	0.593 (.001)	0.448 (.001)
Time discount factor	$\beta$	0.973 (.001)	0.996 (.000)	0.972 (.001)	0.944 (.001)	0.951 (.001)	0.951 (.001)	0.946 (.001)
Wage profile parameters	$\delta_0$	8.922 (.009)	9.862 (.002)	8.680 (.006)	9.389 (.007)	9.197 (.007)	9.143 (.008)	9.211 (.008)
	$\delta_1$	0.073 (.000)	0.111 (.000)	0.073 (.000)	0.063 (.000)	0.070 (.000)	0.075 (.000)	0.074 (.000)
	$\delta_2$	-0.001 (.000)	-0.002 (.000)	-0.001 (.000)	-0.001 (.000)	-0.001 (.000)	-0.001 (.000)	-0.001 (.000)
	$\delta_0^E$	-0.487 (.002)	-0.294 (.000)	-0.450 (.001)	-0.530 (.002)	-0.480 (.002)	-0.478 (.002)	-0.505 (.002)
	$\delta_1^E$	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	$\rho$	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	$\sigma_\nu$	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	$\sigma_\epsilon$	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	$\sigma_i$	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	$\alpha$	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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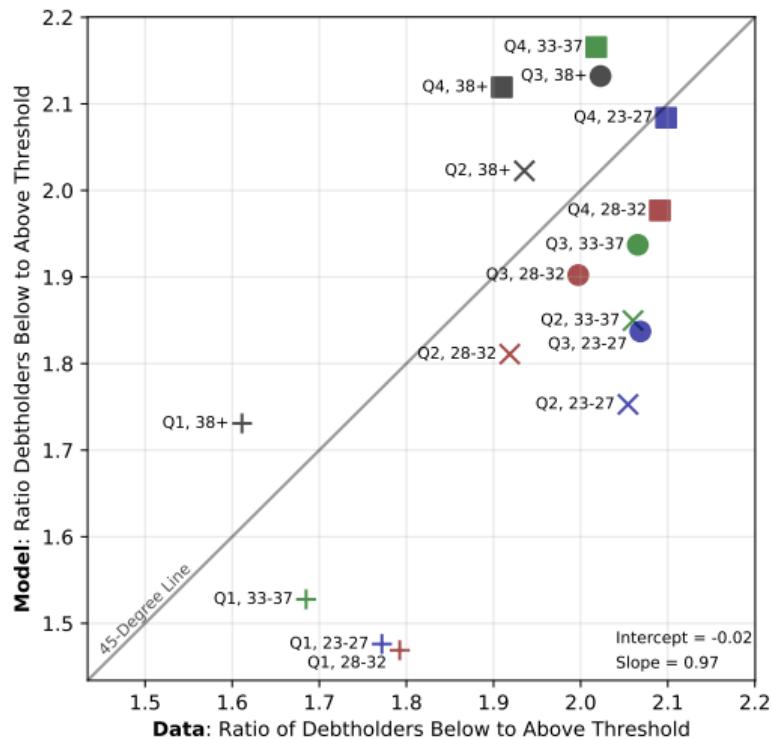
## ADDITIONAL MODEL RESULTS: POSITIVE

- 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 

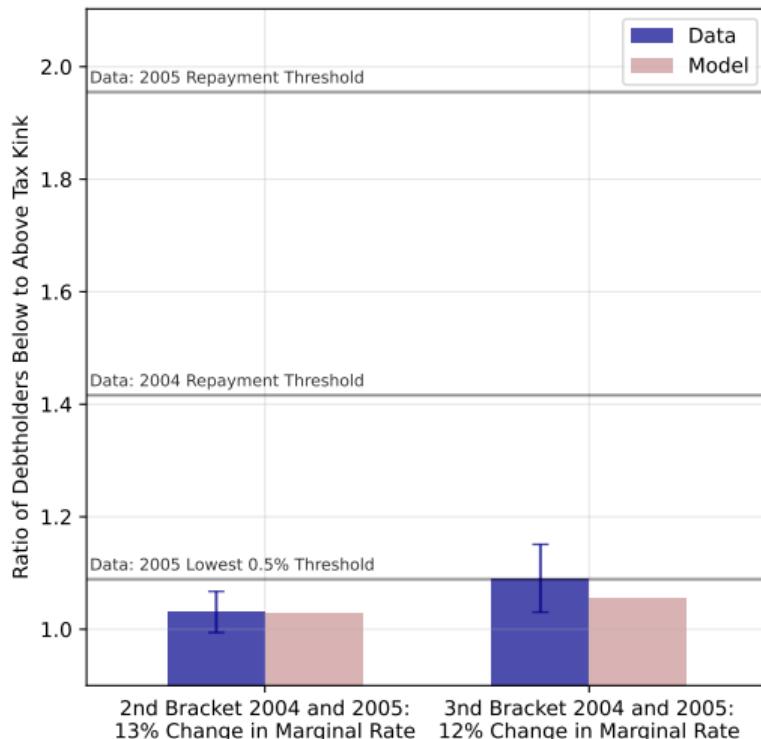
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# VALIDATION OF BASELINE MODEL ON NONTARGETED BUNCHING

## Heterogeneity by Debt and Age



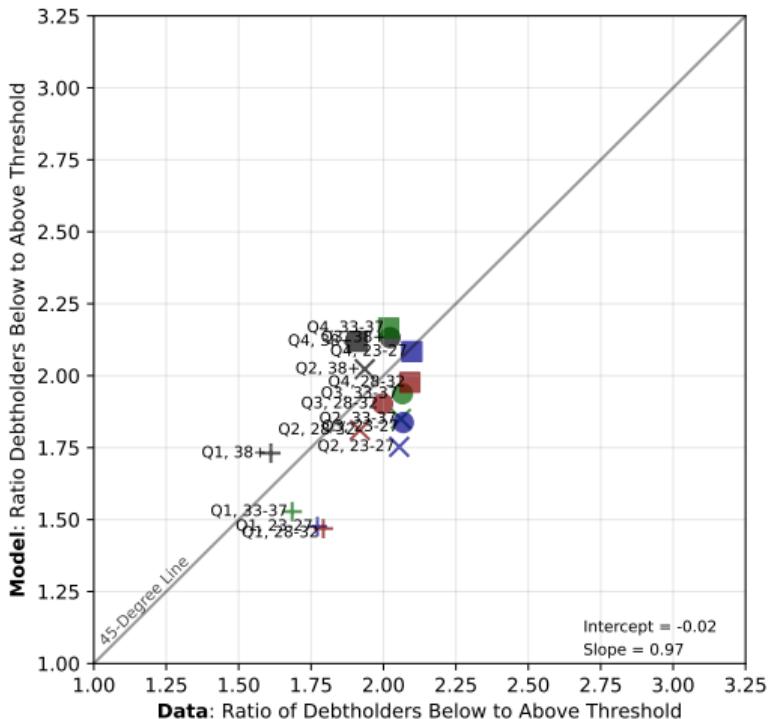
## Bunching at Changes in Tax Rates



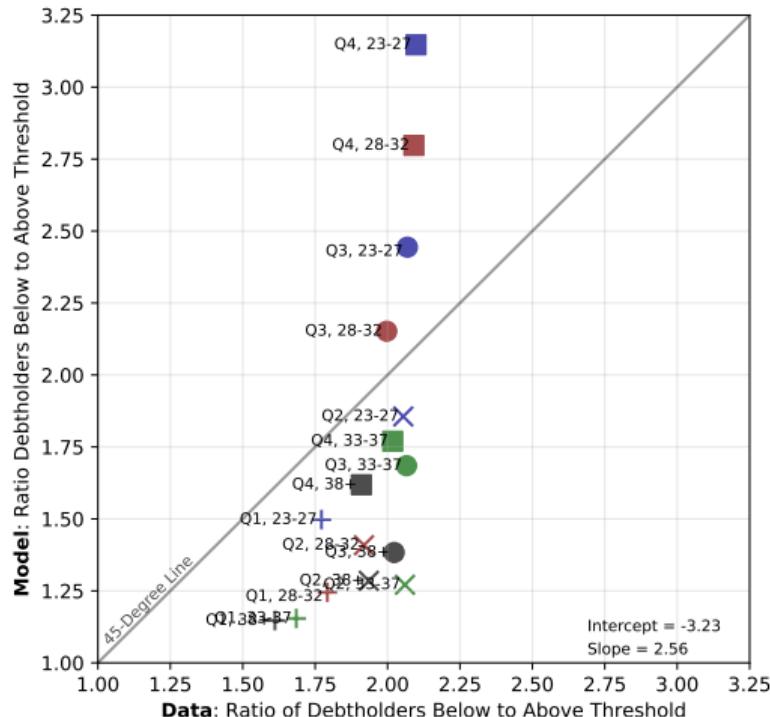
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# LEARNING-BY-DOING MODEL FITS WORSE THAN BASELINE MODEL

## Baseline Model

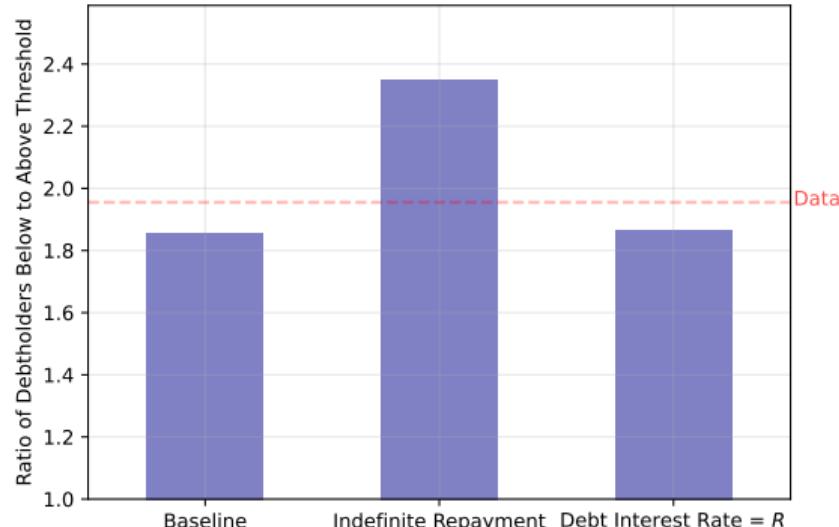
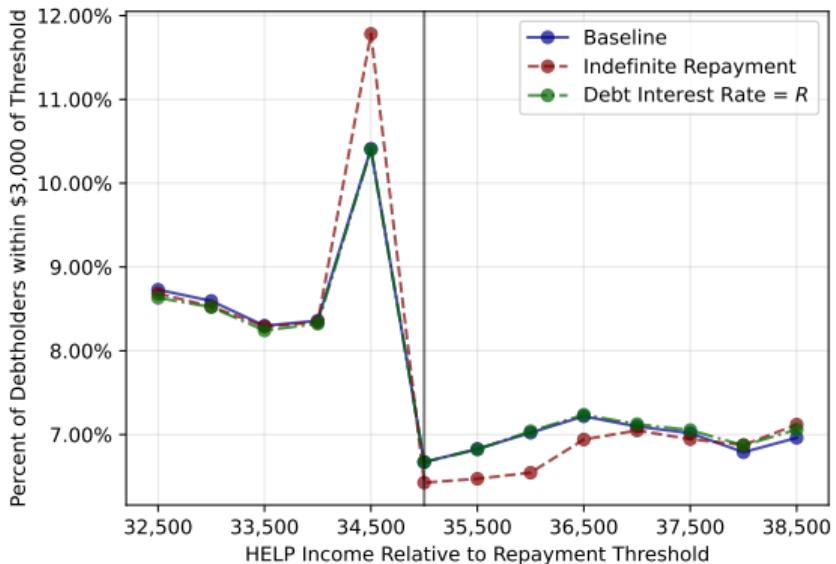


## Learning-by-Doing Model



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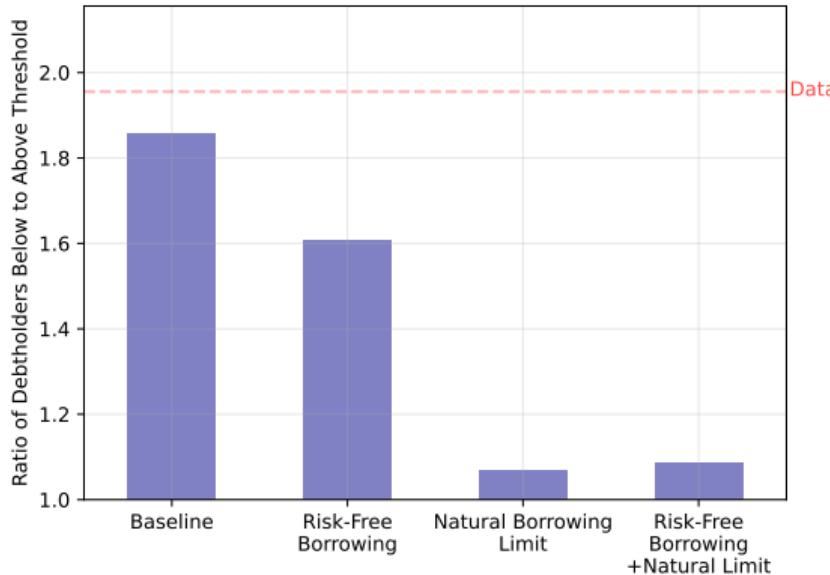
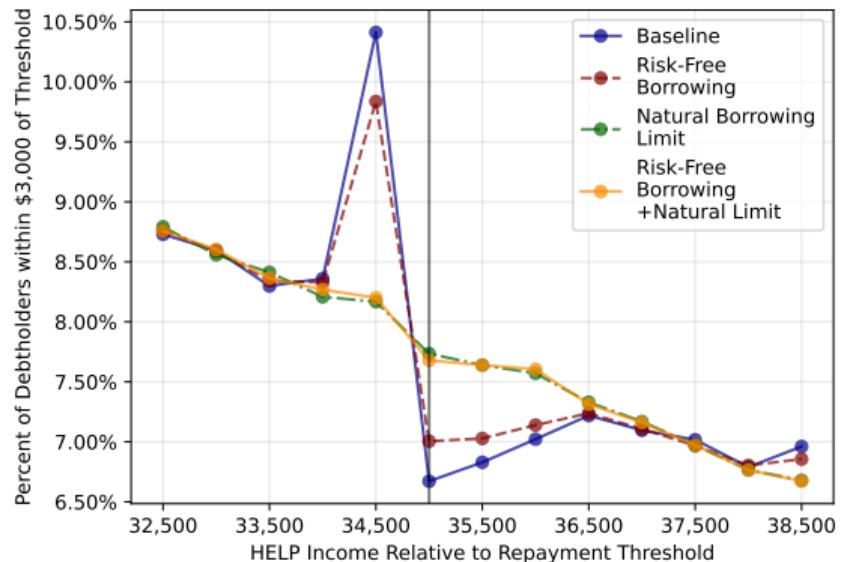
# DYNAMICS: BUNCHING DEPENDS ON PROBABILITY OF REPAYMENT



- **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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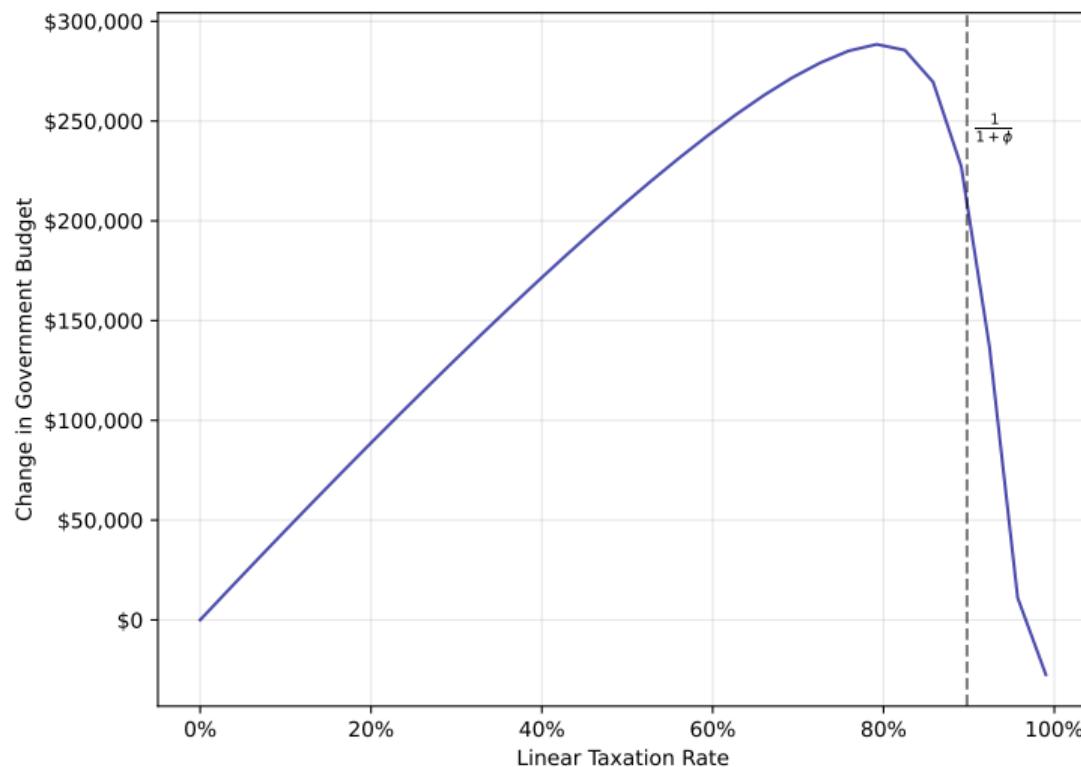
# LIQUIDITY: BORROWING CONSTRAINTS AMPLIFY RESPONSES



- **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%**

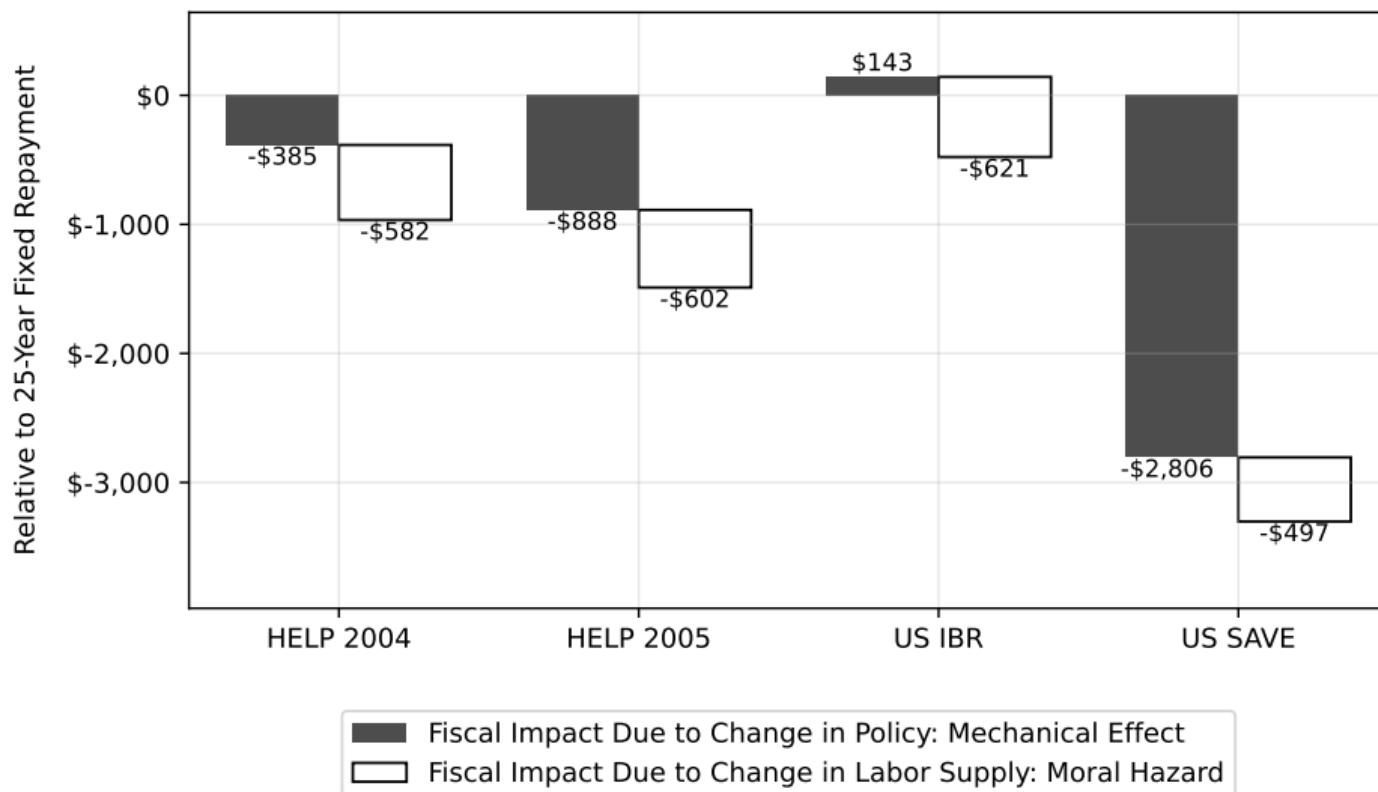
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# LAFFER CURVE FROM LINEAR TAXATION



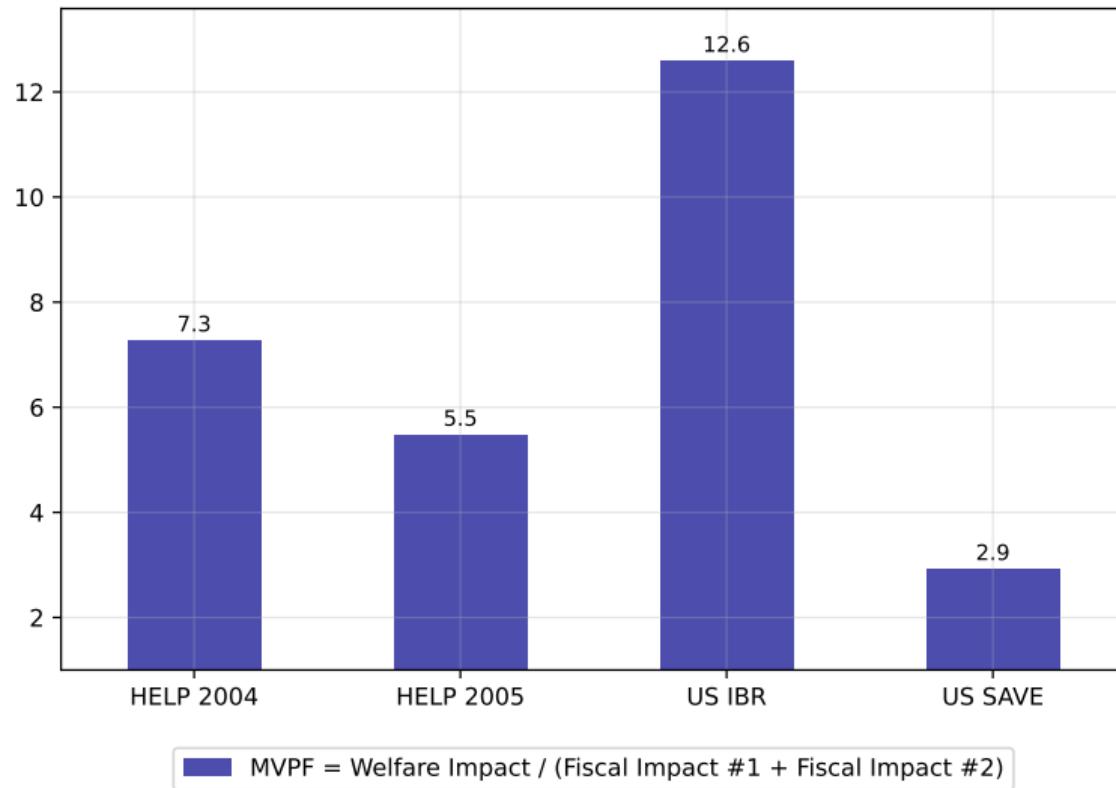
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# DECOMPOSITION OF FISCAL IMPACT: ENDOGENOUS LABOR SUPPLY



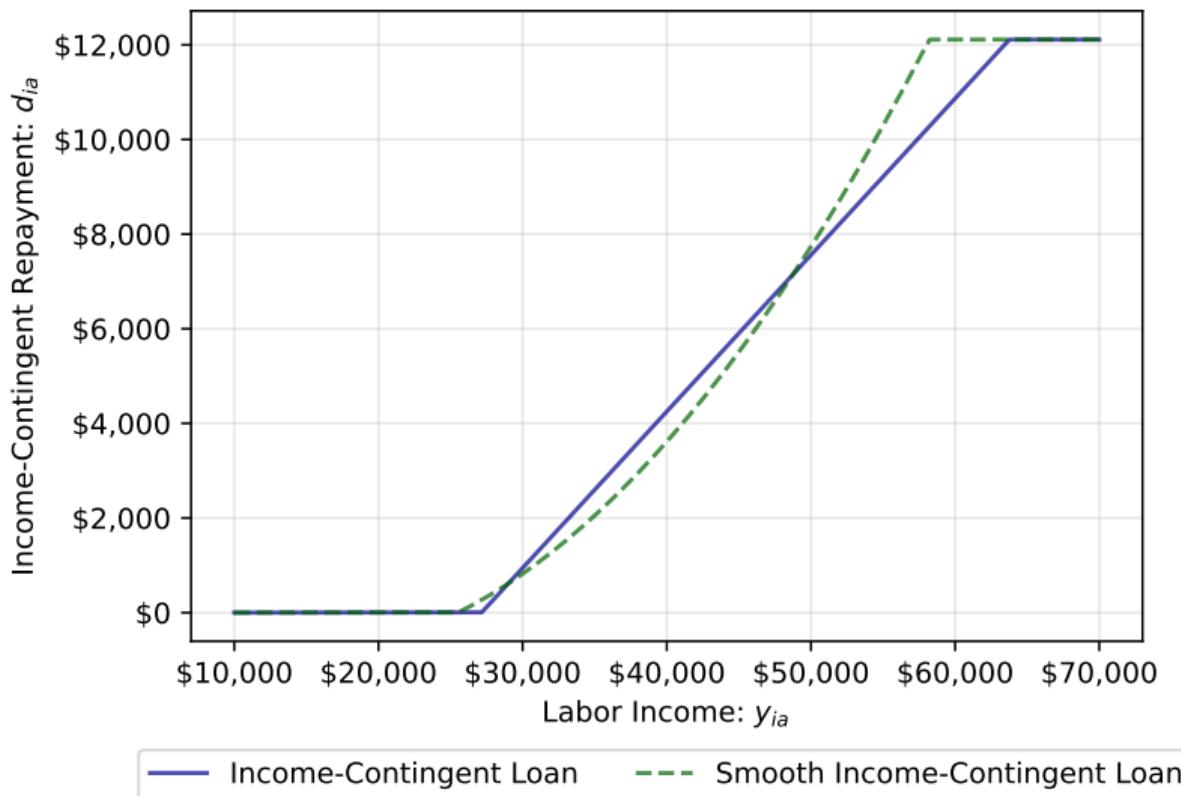
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# MARGINAL VALUE OF PUBLIC FUNDS



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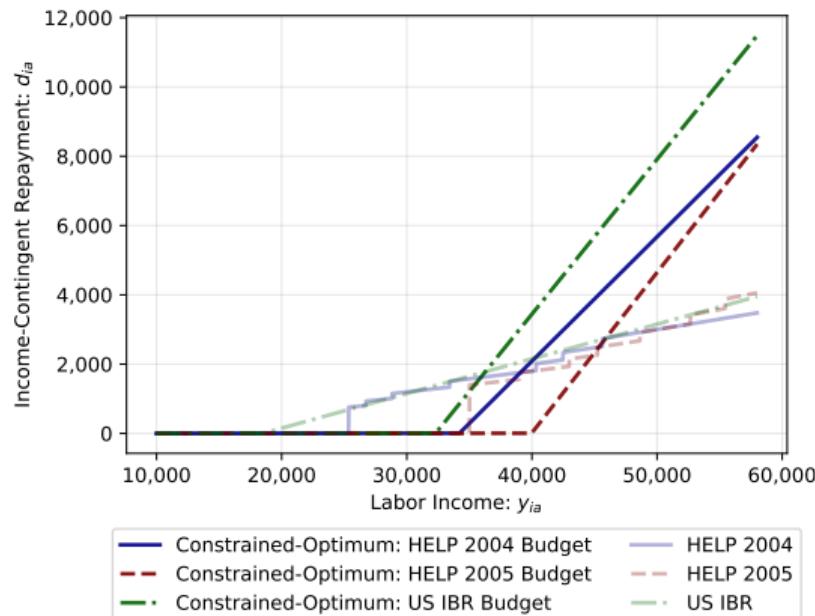
# SOLUTION TO CONSTRAINED-PLANNER'S PROBLEM: QUADRATIC



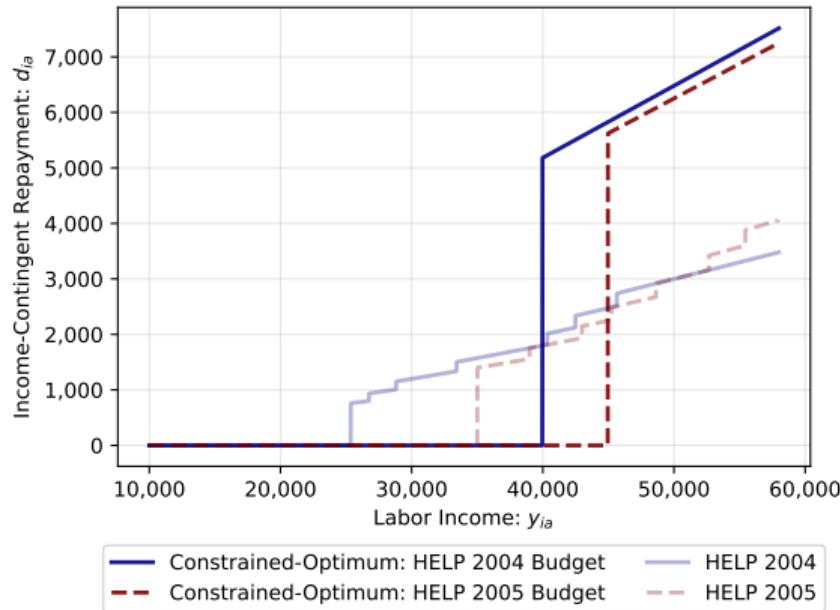
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# OPTIMAL VERSUS EXISTING INCOME-CONTINGENT LOANS

## Change in Marginal Rate

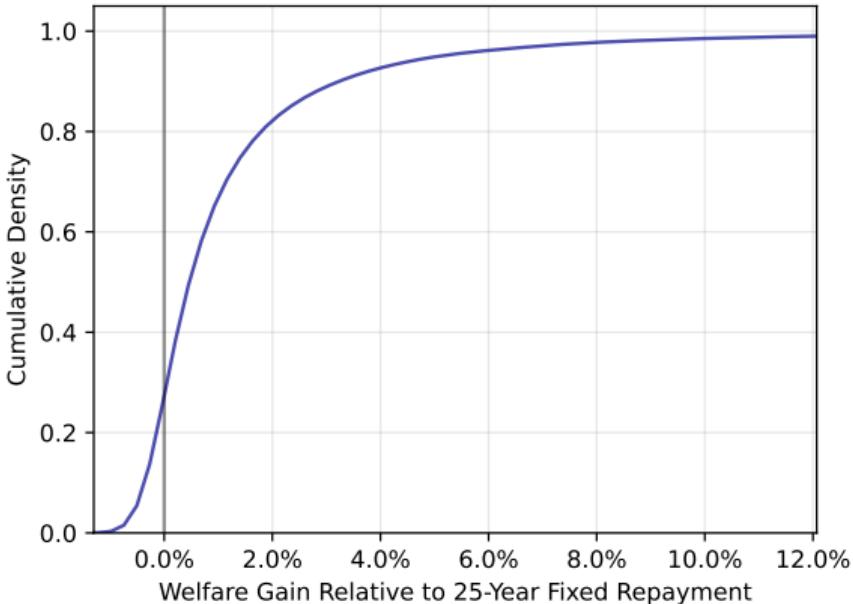
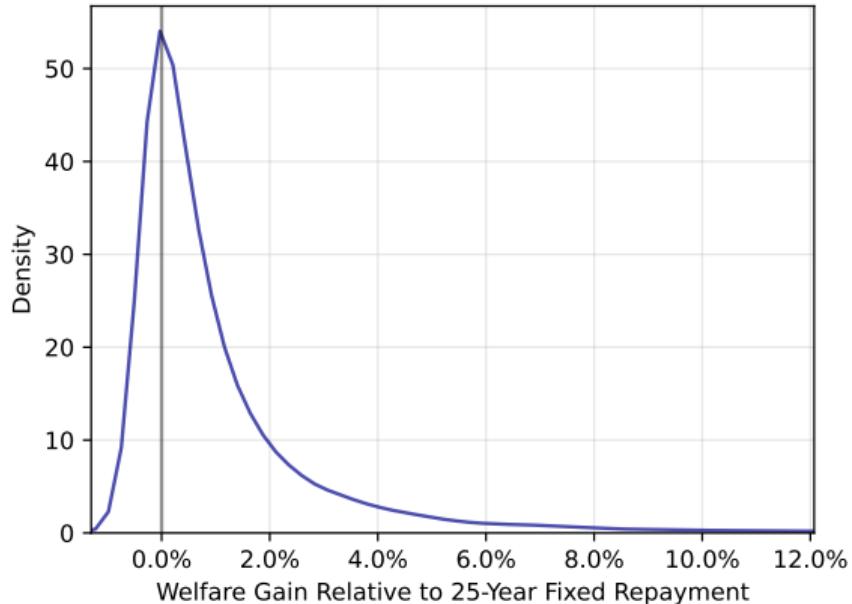


## Change in Average Rate



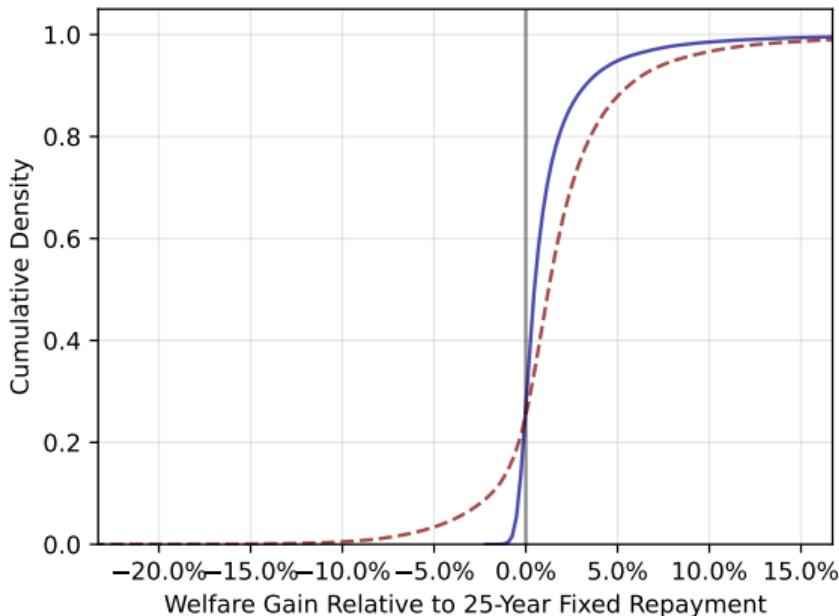
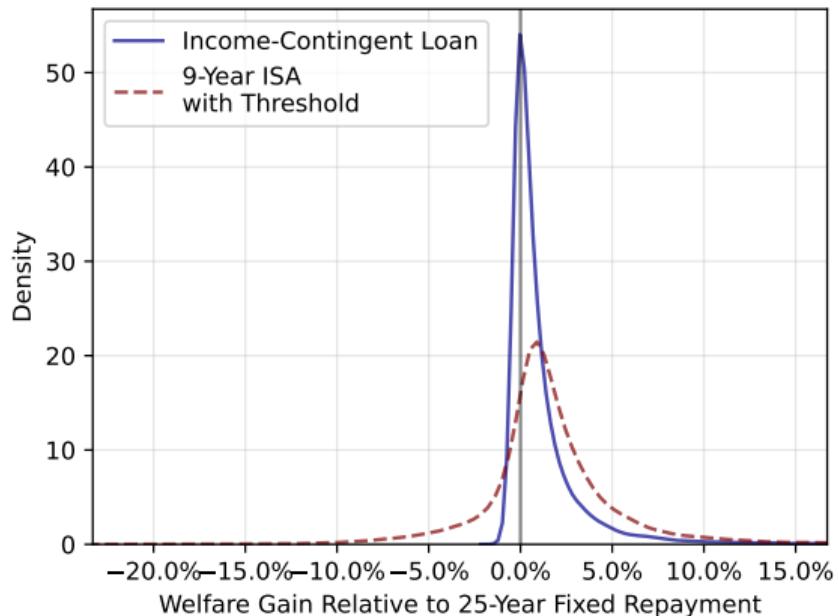
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# DISTRIBUTION OF INITIAL WELFARE GAINS: ICL



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

# DISTRIBUTION OF INITIAL WELFARE GAINS: ICL vs. EQUITY

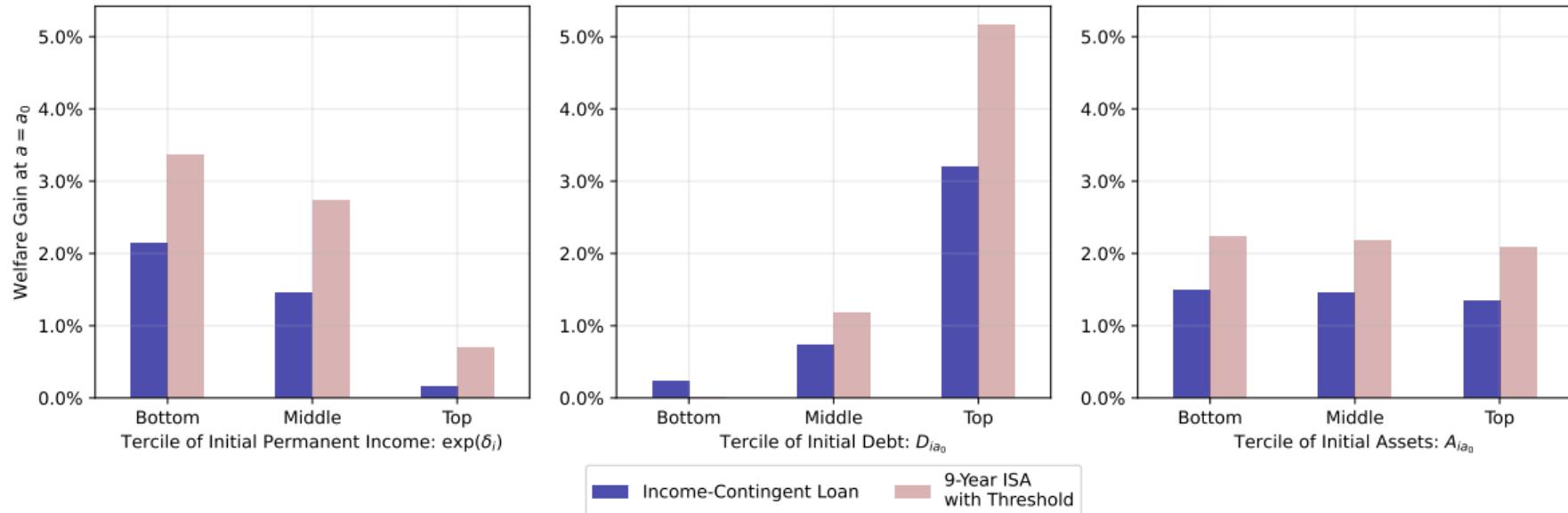


- **18%** of borrowers have welfare loss above 0.5% for equity vs. **1.2%** for ICL

▶ Heterogeneity by Initial States

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# HETEROGENEITY IN WELFARE GAINS ACROSS INITIAL STATES



▶ Losers under ICL

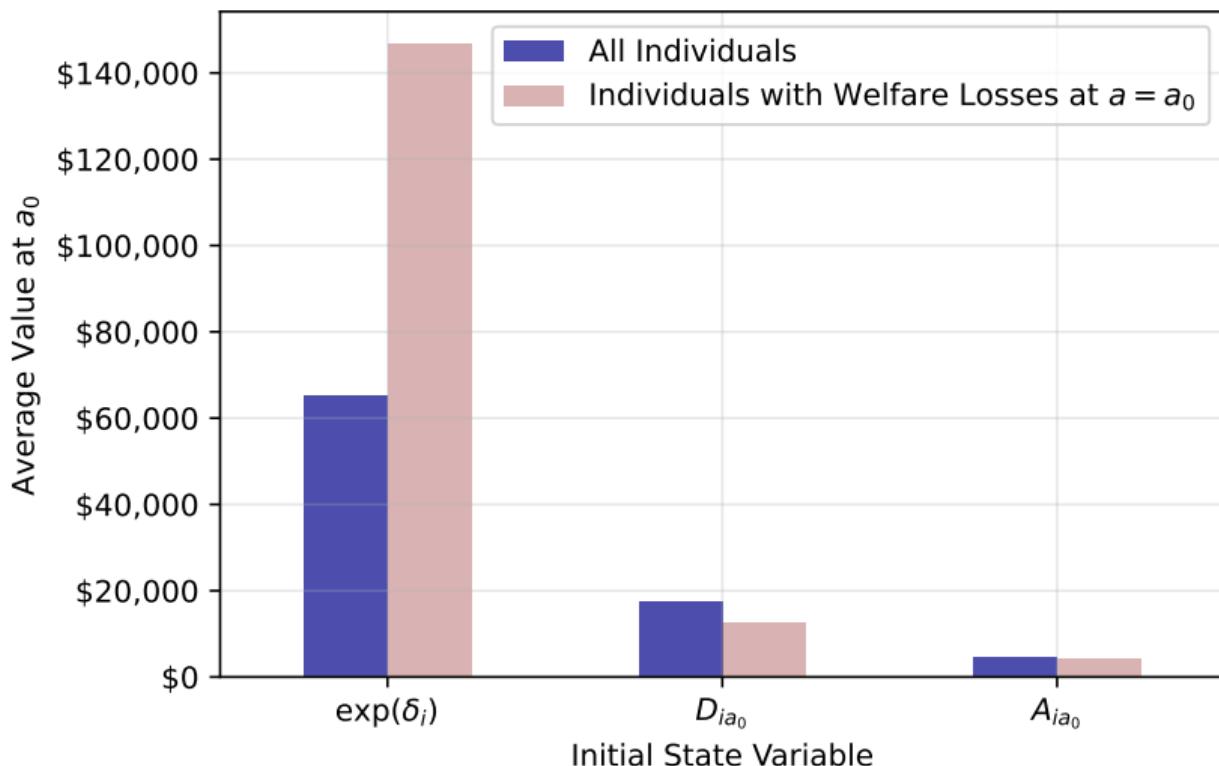
▶ Heterogeneity by Age

▶ Heterogeneity by Initial Debt

◀ Back: ICL Gain

◀ Back: Contracts

# INDIVIDUALS WITH INITIAL WELFARE LOSSES: ICL



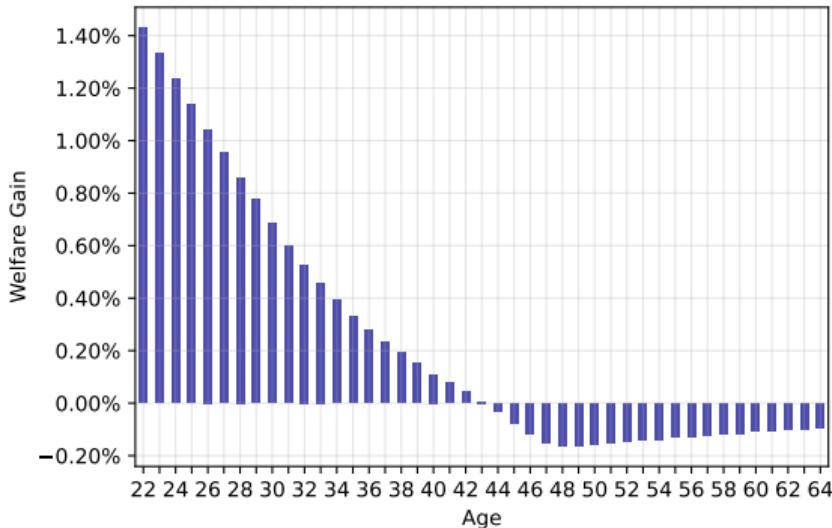
► Heterogeneity by Age

◀ Back: ICL Gain

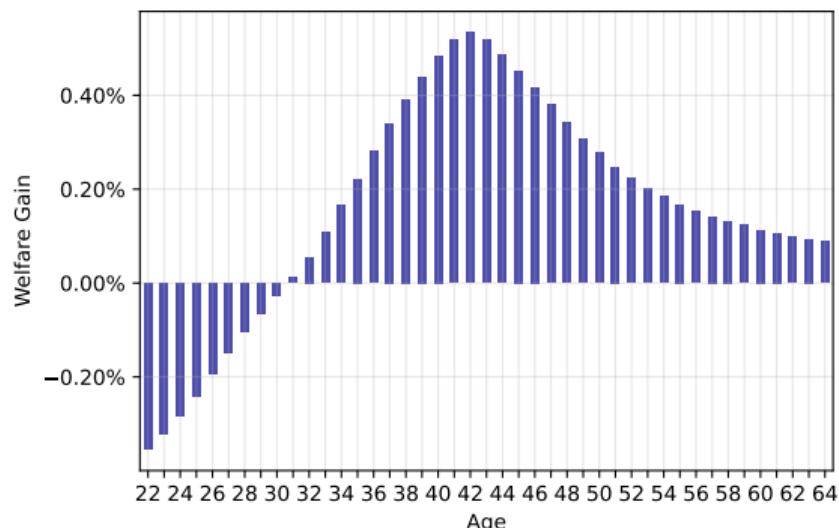
◀ Back: Contracts

# WELFARE GAINS BY AGE

**ICL vs. 25-Year Fixed**



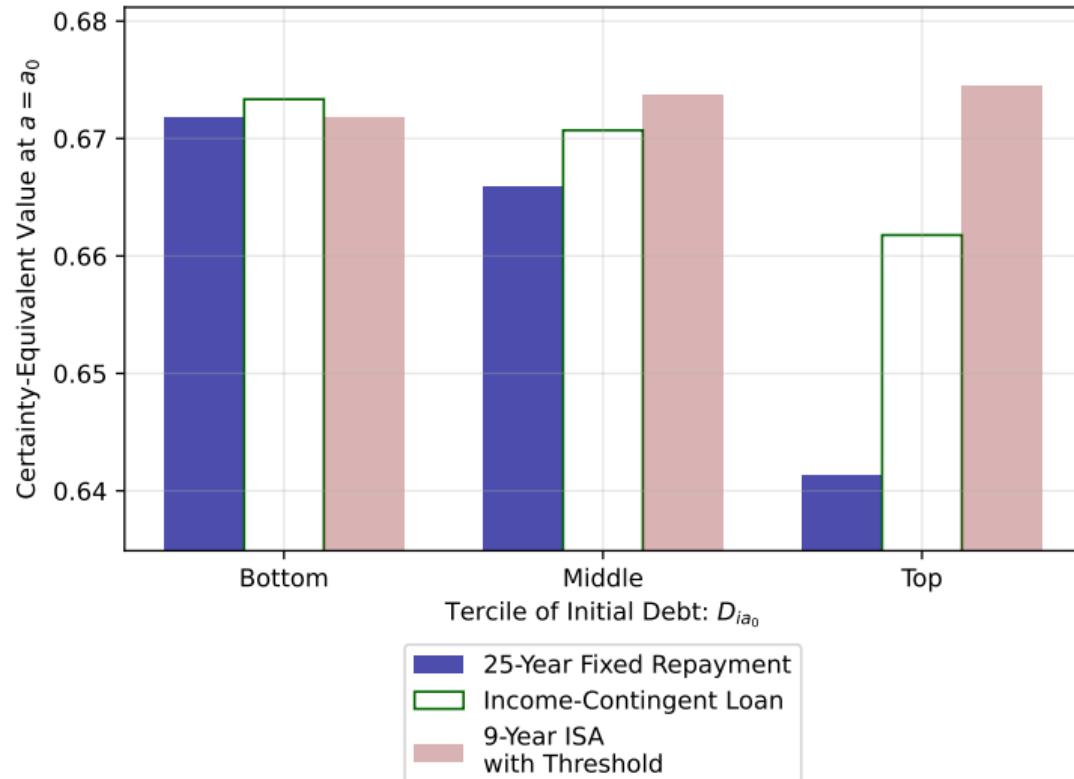
**ICL + 20-Year Forgiveness vs. ICL**



◀ Back: ICL Gain

◀ Back: Contracts

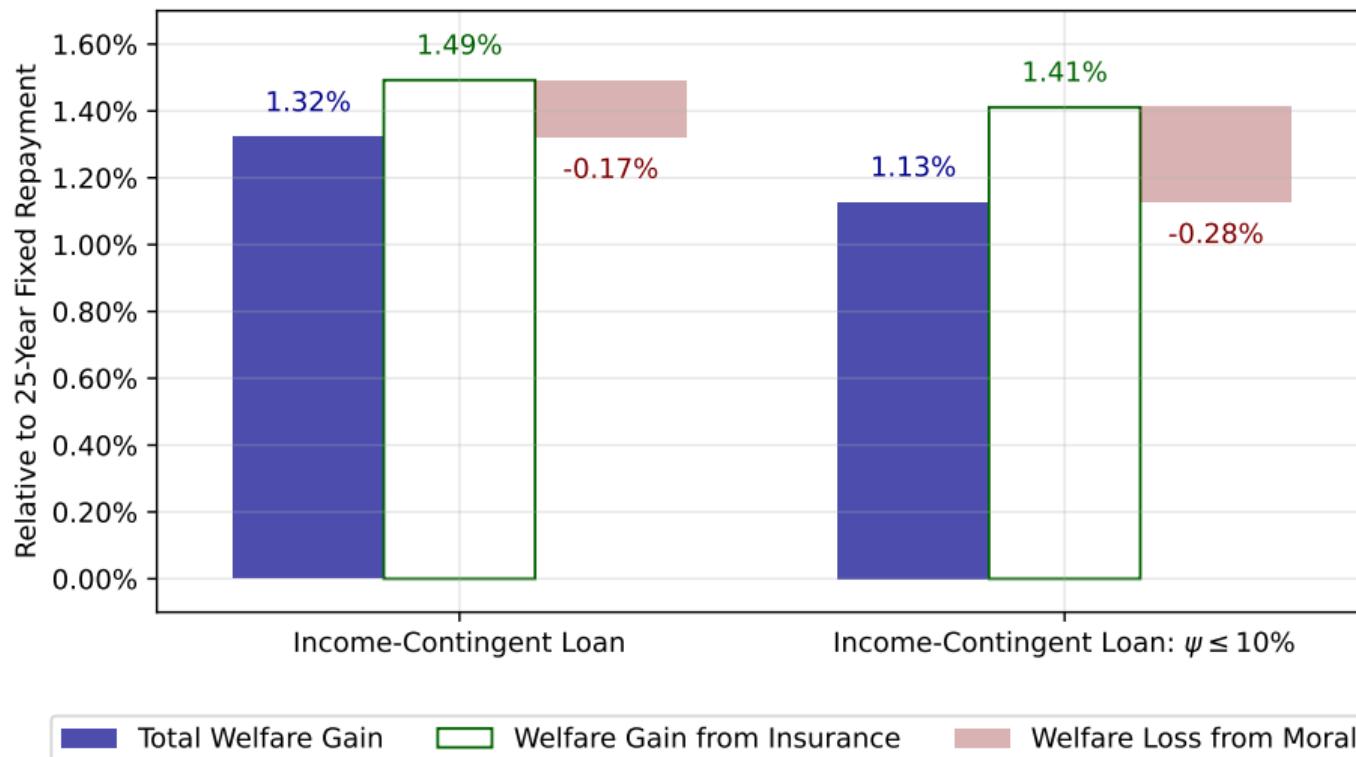
# CERTAINTY-EQUIVALENTS ACROSS INITIAL DEBT



◀ Back: ICL Gain

◀ Back: Contracts

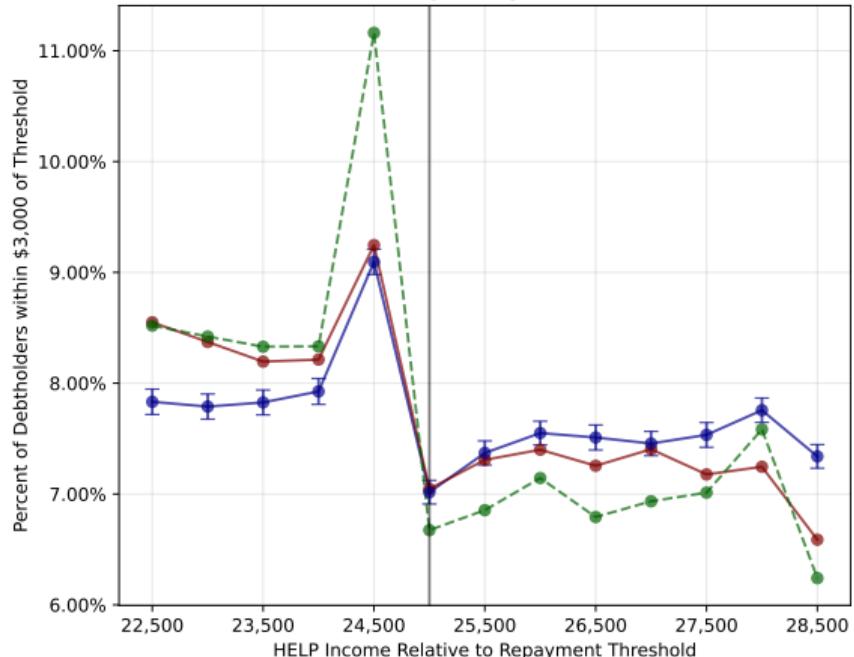
# CONSTRAINING REPAYMENT RATE REDUCES WELFARE GAINS



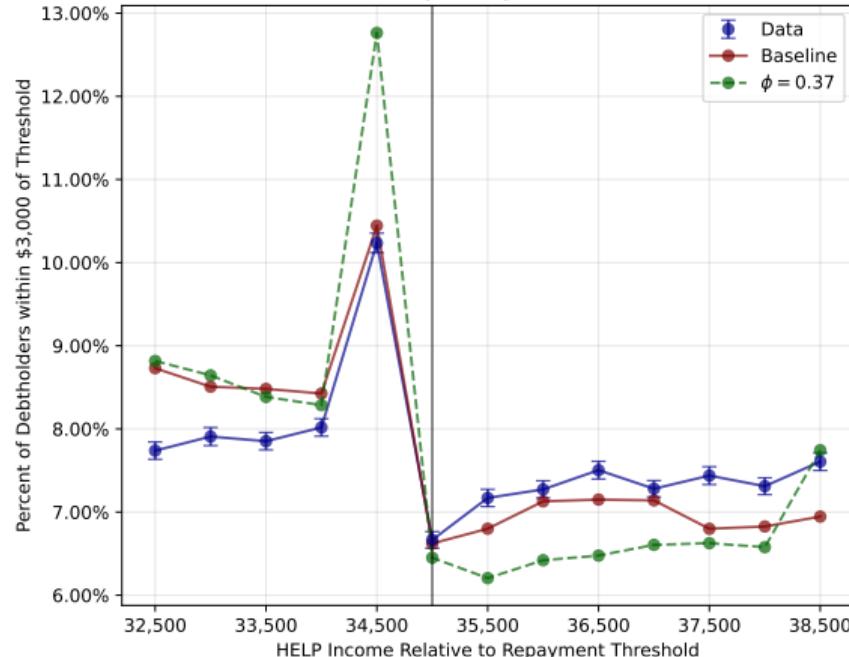
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# FIT OF MODEL IN WHICH FIXED REPAYMENT IS OPTIMAL

Before Policy Change: 2002-2004



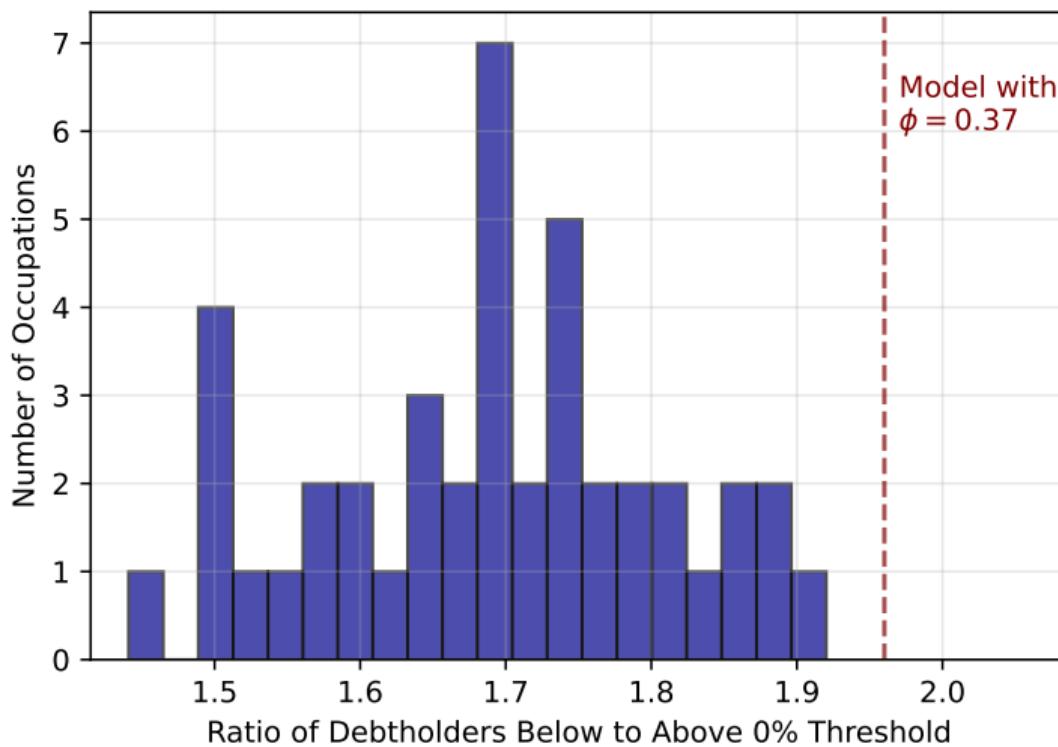
After Policy Change: 2005-2007



▶ Occupations

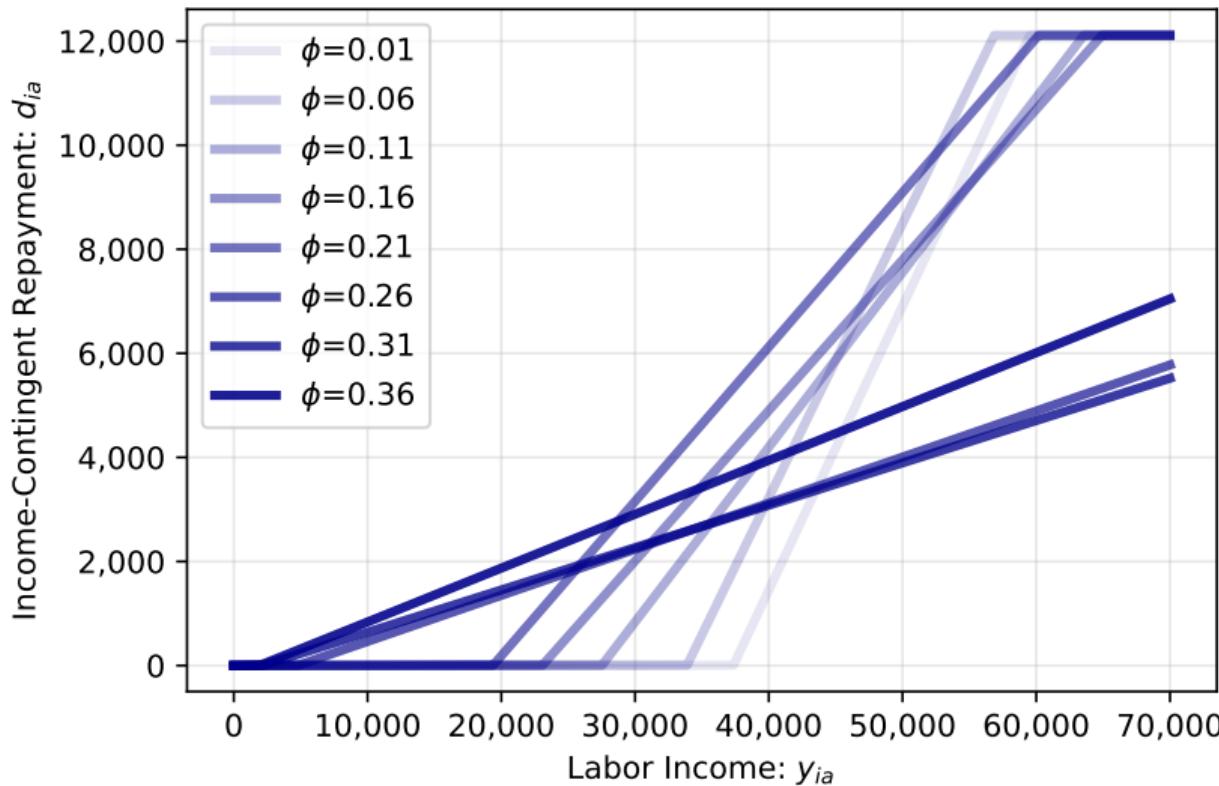
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# BUNCHING WHEN FIXED REPAYMENT IS OPTIMAL vs. OCCUPATIONS



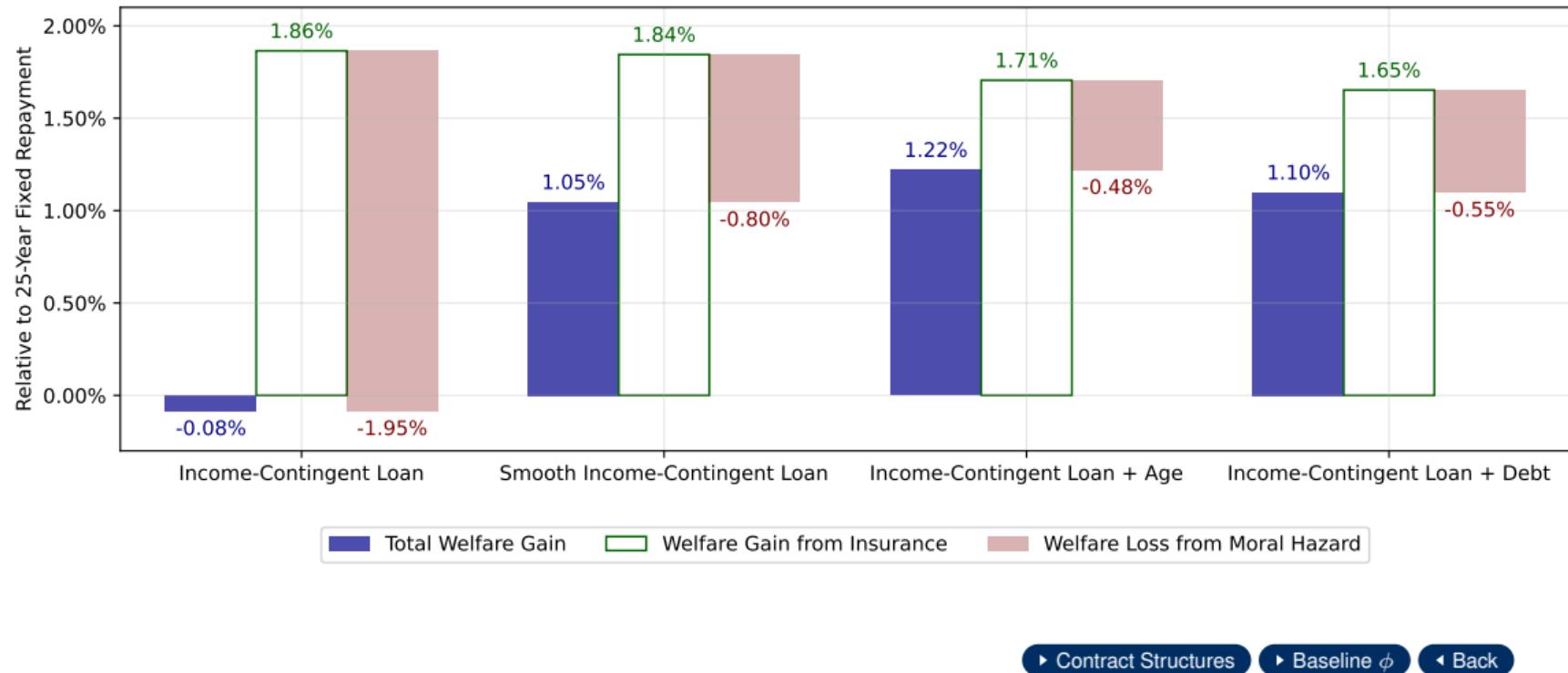
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# How INCOME-CONTINGENT LOANS VARY WITH $\phi$

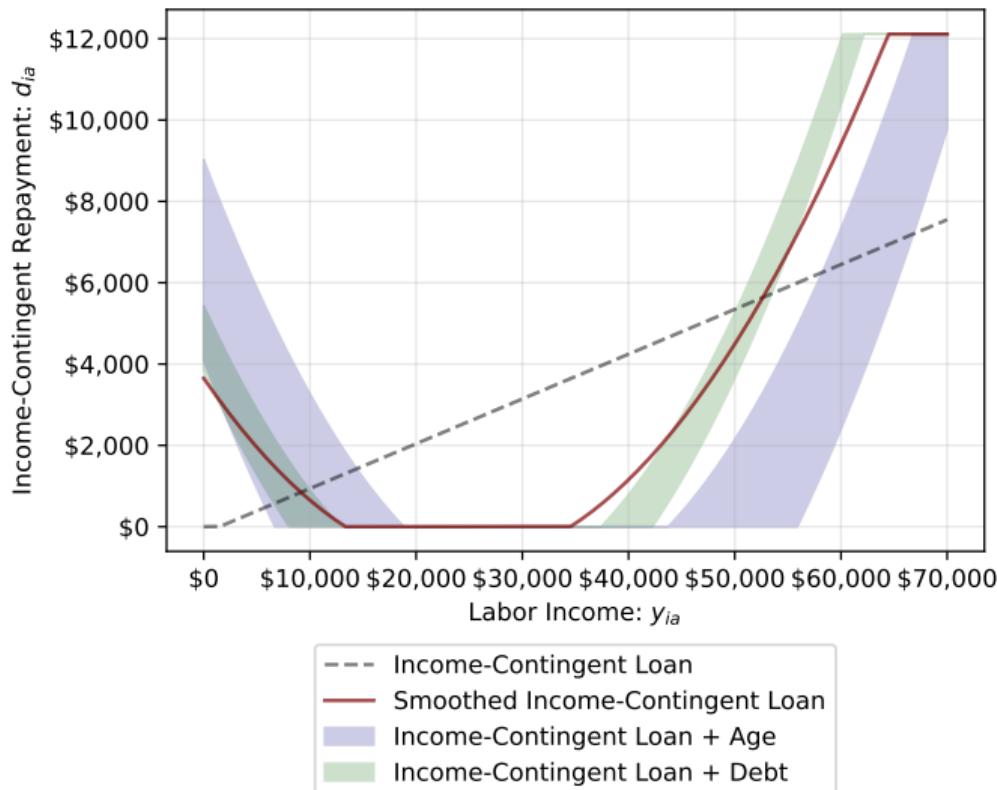


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# ALTERNATIVE CONTRACTS REDUCE WELFARE COST OF MORAL HAZARD

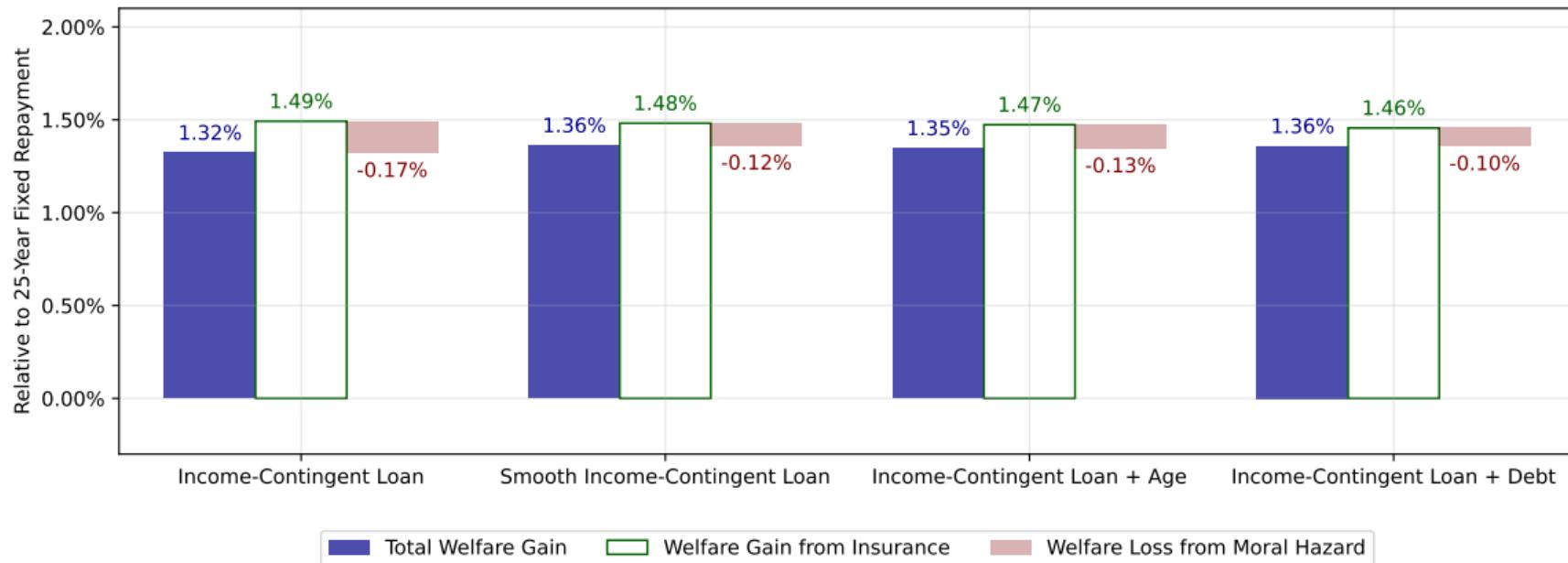


# ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: $\phi = 0.37$



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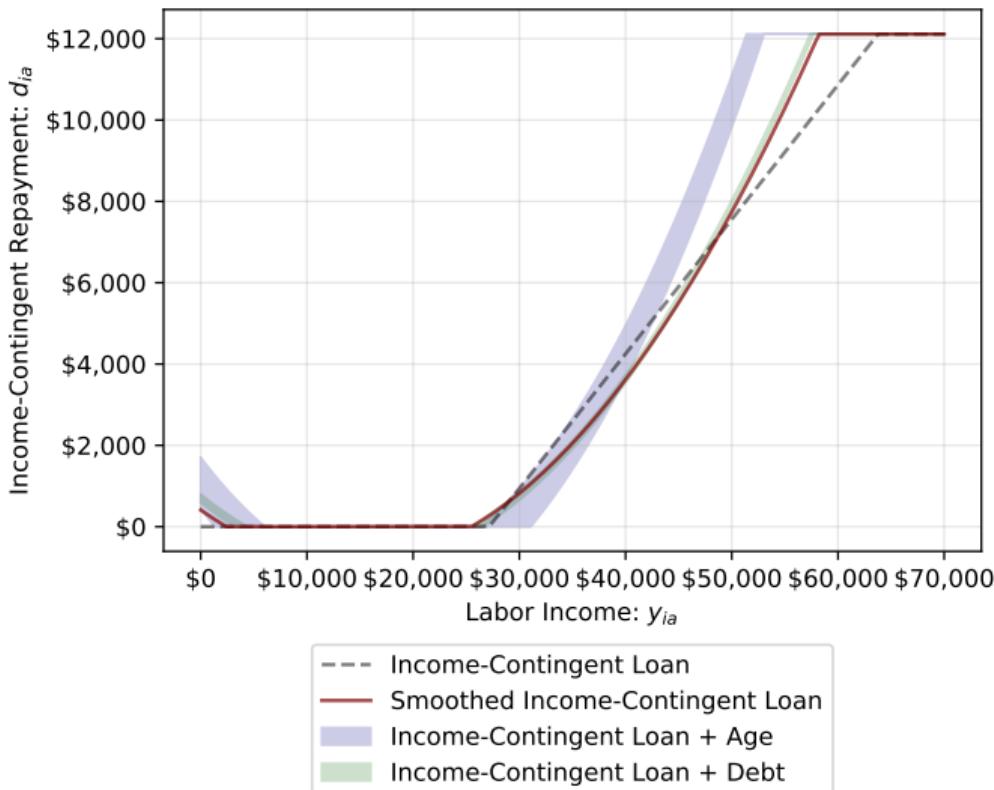
# REDUCING WELFARE COST OF MORAL HAZARD: BASELINE $\phi$



▶ Contract Structures

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# ALTERNATIVE FORMS OF INCOME-CONTINGENT LOANS: BASELINE $\phi$



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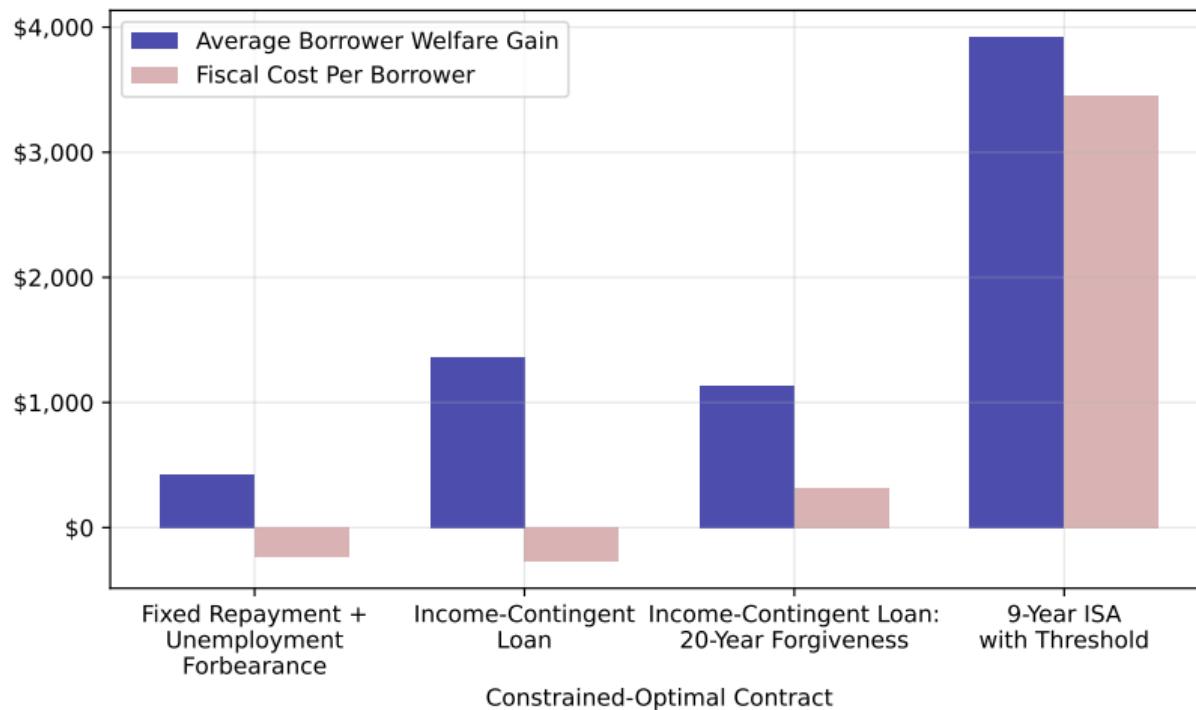
# EFFECTS OF ENDOGENOUS CONTRACT SELECTION

	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
<b>Consumption-Equivalent Welfare Gains</b>		
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

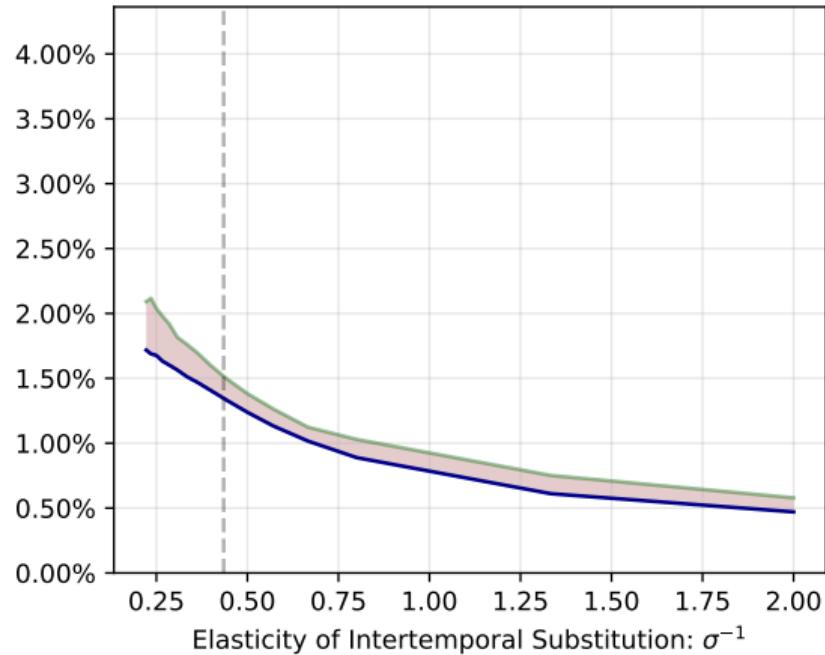
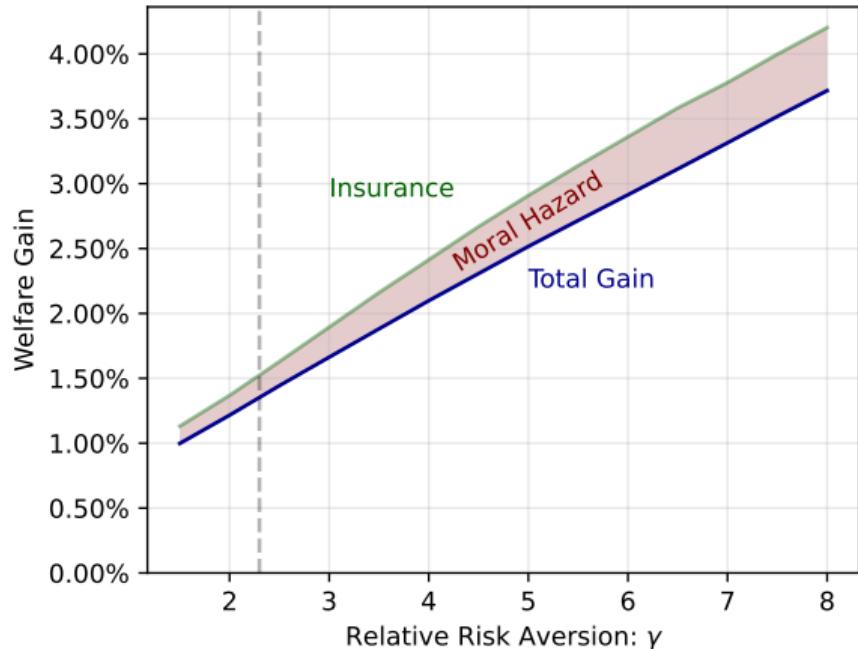
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## ADDITIONAL MODEL RESULTS: NORMATIVE

- 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



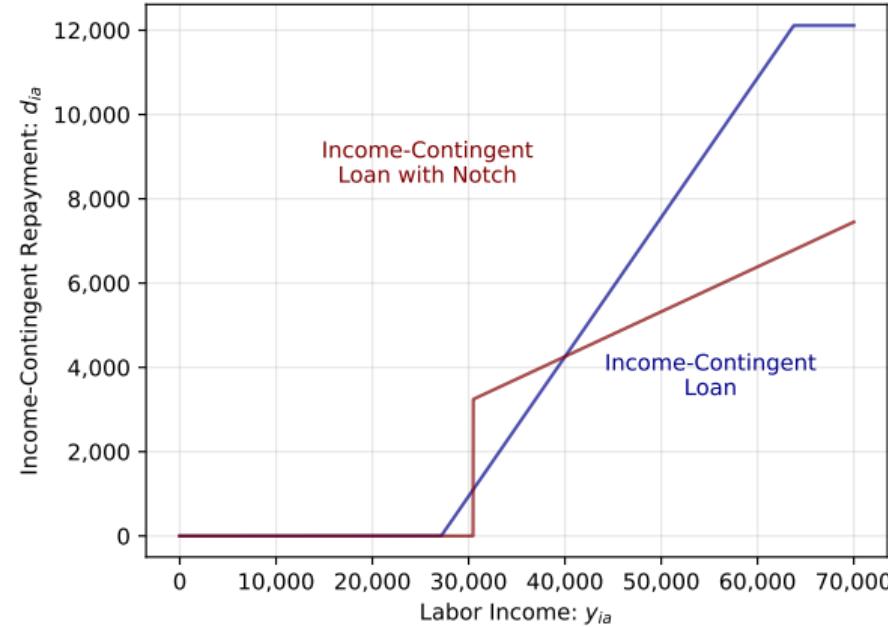
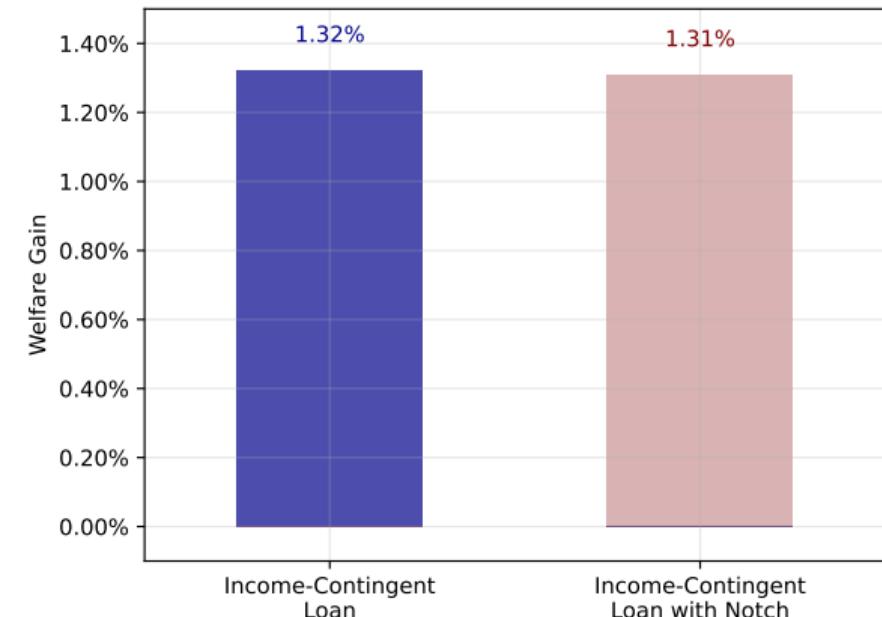
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# EFFECTS OF CHANGING FIXED COST AND CALVO PROBABILITY

Difference from Baseline Model	Welfare Gain = Insurance	+ Moral Hazard	$\psi^*$	$K^*$
(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
<b>Baseline Model</b>	<b>1.32%</b>	<b>1.47%</b>	<b>-0.15%</b>	<b>33% \$27,147</b>

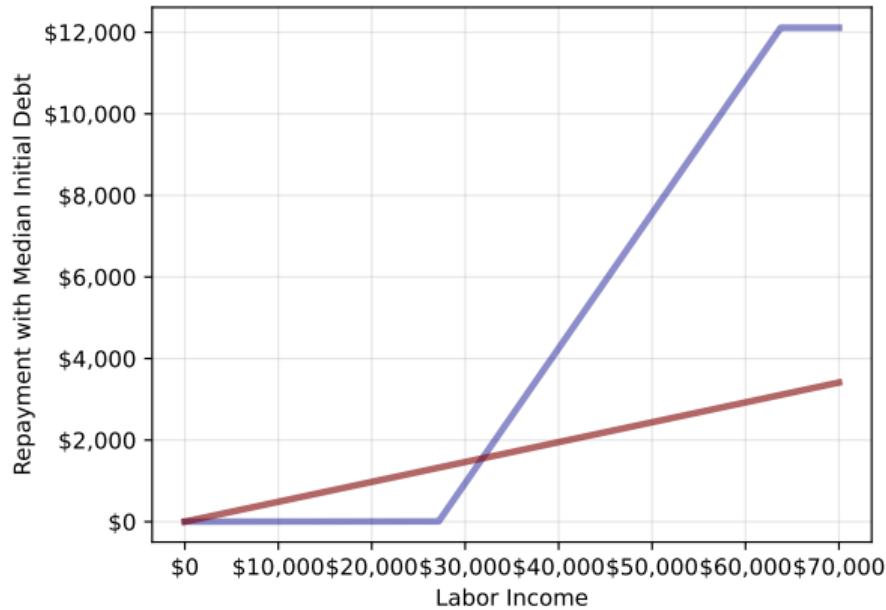
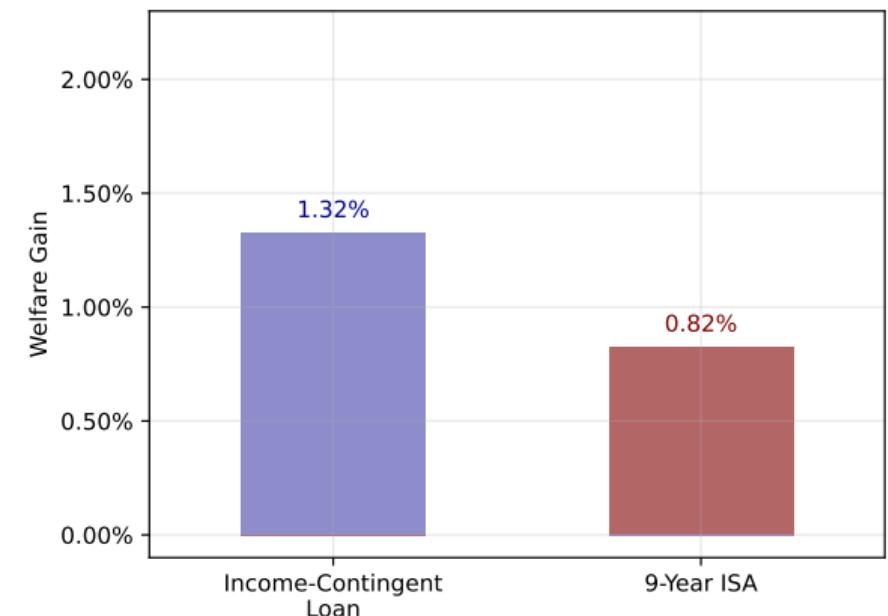
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# No LOSS FROM DISCONTINUITY IN AVERAGE REPAYMENT RATE



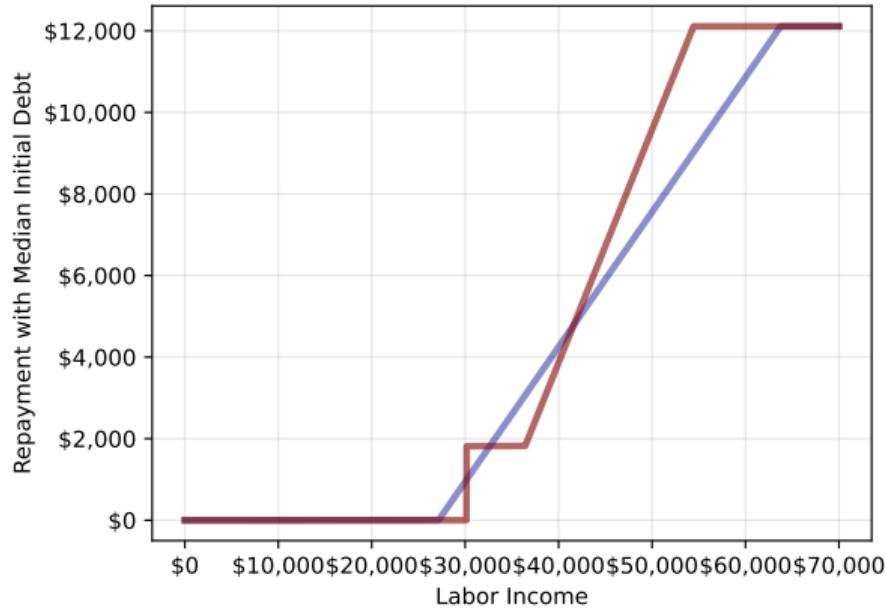
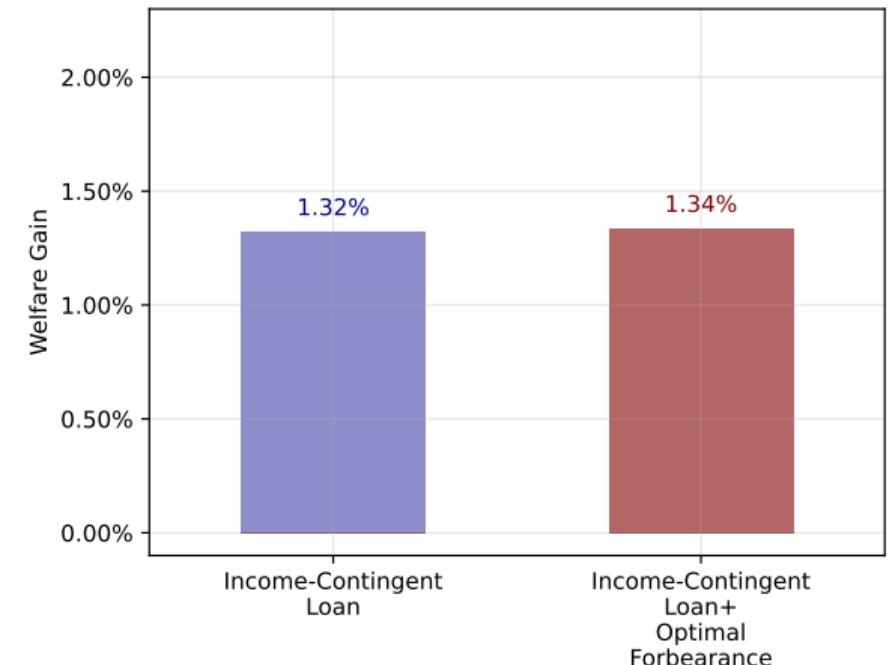
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# PURE EQUITY DOES WORSE THAN INCOME-CONTINGENT LOAN



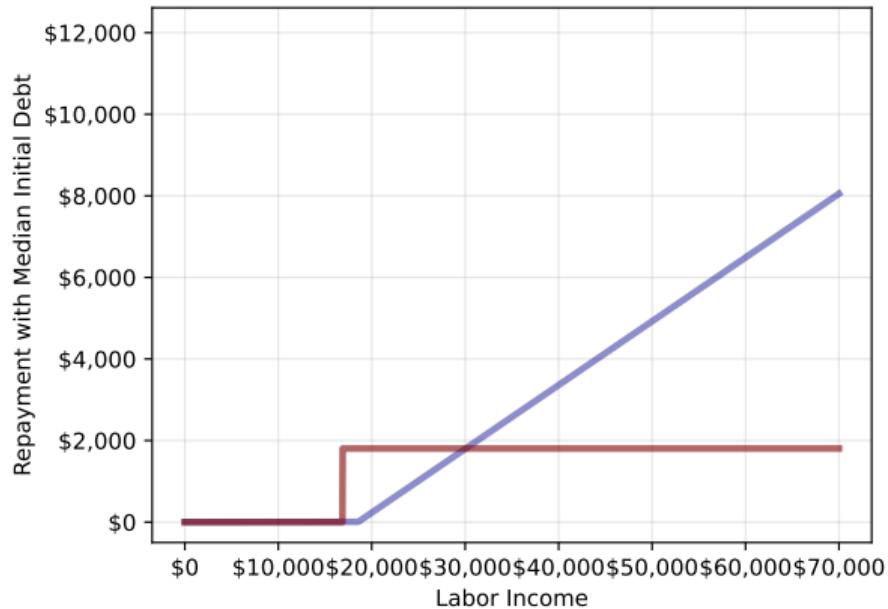
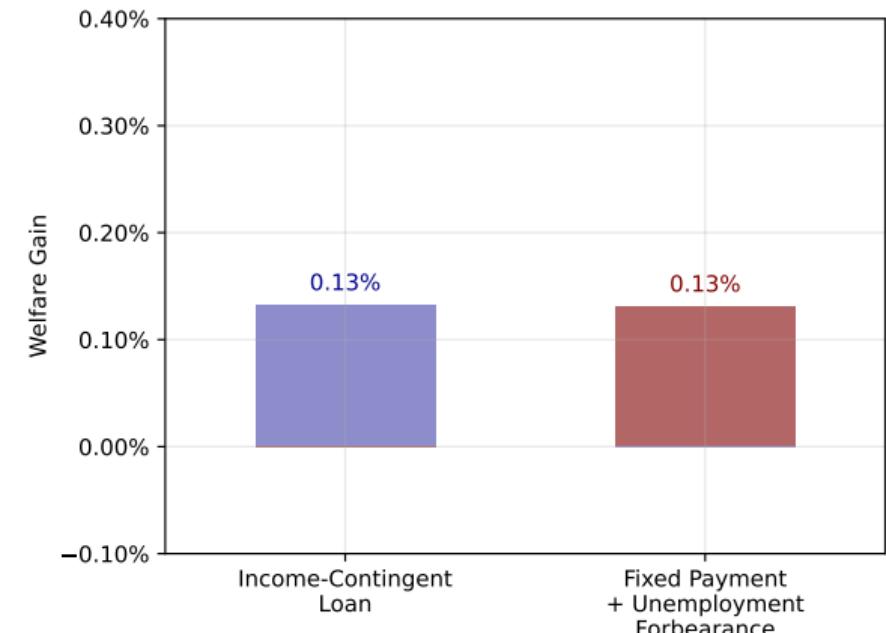
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# No GAINS TO ADDING FORBEARANCE TO INCOME-CONTINGENT LOANS



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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	$\psi^*$	$K^*$
(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
	<b>Baseline Model</b>	<b>1.32%</b>	<b>1.47%</b>	<b>-0.15%</b>	<b>33%</b>	<b>\$27,147</b>

◀ Back: ICL Gain

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# ROBUSTNESS TO ALTERNATIVE MODELS OF FRICTIONS

Difference from Baseline Model	Welfare Gain = Insurance	+ Moral Hazard	$\psi^*$	$K^*$
(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
<b>Baseline Model</b>	<b>1.32%</b>	<b>1.47%</b>	<b>-0.15%</b>	<b>33% \$27,147</b>

- 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

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