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

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Student loans with income-contingent repayment insure borrowers against income risk but can reduce their incentives to earn more. Using a change in Australia's income-contingent repayment schedule, I show that borrowers reduce their labor supply to lower their repayments. These responses are larger among borrowers with more hourly flexibility, a lower probability of repayment, and tighter liquidity constraints. I use these responses to estimate a dynamic model of labor supply with frictions that generate imperfect adjustment. My estimates imply that the labor supply responses to income-contingent repayment limit the optimal amount of insurance in government-provided student loans. However, these responses are too small to justify fixed-repayment contracts: restructuring existing student loans from fixed repayment to a constrained-optimal income-contingent loan—while keeping the tax and transfer system unchanged—increases borrower welfare by the equivalent of a 0.8% increase in lifetime consumption at no additional fiscal cost. *JEL codes:* C54, D15, E21, G28, H31, J22.

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I. Introduction

In many countries, students finance higher education through government-provided student loans. These loans are the second-largest household liability in the United States at $1.6 trillion and account for 10% of household debt in the United States and United Kingdom. Traditionally, government-provided student loans have resembled debt contracts, where borrowers make fixed payments after graduation to repay their loan balances. Because student loans are generally not dischargeable in bankruptcy, these contracts force borrowers to bear most of the risk associated with the returns to higher education. Unfortunately, the risk of low income after graduation materializes for many borrowers, with 25% of U.S. borrowers defaulting within five years (Hanson 2022).

One potential policy to provide more insurance against income risk is to make student loans equity-like by linking repayments to borrowers' incomes. This idea has been discussed extensively (Friedman 1955; Palacios 2004; Shiller 2004; Chapman 2006), and governments in the United States, United Kingdom, Canada, and Australia have recently implemented it by providing income-contingent loans. In contrast to nondischargeable debt contracts, income-contingent repayment provides insurance by reducing payments as a borrower's income declines. However, this insurance potentially comes at the cost of creating moral hazard: because repayments increase with income, borrowers have an

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incentive to reduce their labor supply to decrease repayments. Empirically, income-contingent repayment appears effective at providing insurance (Herbst 2023), but there is no consensus on the moral hazard effects it creates (Yannelis and Tracey 2022).

The objective of this article is to study two questions. First, how does income-contingent repayment affect borrowers' labor supply? Second, what is the optimal form of income-contingent repayment that balances this moral hazard, if it exists, with providing insurance? To identify labor supply responses empirically, I leverage administrative data and policy variation from the Australian Higher Education Loan Programme (HELP), the first program to provide income-contingent loans nationwide. I then use these responses to estimate a dynamic model of labor supply and study the implications of various repayment contracts. In my normative analyses, I consider a government that maximizes borrower welfare, taking education and borrowing choices as given. Therefore, my results are informative about the effects of a (mandatory) debt restructuring among existing borrowers (e.g., the \$1.6 trillion of outstanding U.S. student loans) whose ex ante choices are fixed by definition. My analyses also treat the existing tax and transfer system, which is designed for the entire population and constrained by the political system, as given.[1]

My main empirical finding is that borrowers reduce their labor supply to lower repayments on income-contingent loans. These responses are larger among borrowers with more hourly flexibility, a lower probability of repayment, and who are more liquidity-constrained. However, my structural estimation shows that these responses are consistent with a moderate (Frisch) elasticity of labor supply and substantial frictions that limit labor supply adjustment. On the normative side, my estimates imply that moral hazard limits the optimal amount of insurance, but there are still significant welfare gains from income-contingent repayment. Specifically, restructuring from a fixed-repayment contract to a constrained-optimal income-contingent loan increases borrower welfare by the equivalent of 0.8% of lifetime consumption at no additional fiscal cost. Adding forbearance to fixed-repayment contracts is a poor substitute for

1. See Stantcheva (2017) for a joint analysis of the tax system and human capital financing policies.

income-contingent loans because it does not accelerate repayments from high-income borrowers. In sum, my results suggest that income-contingent repayment creates moral hazard that affects contract design but is too small to justify fixed-repayment contracts.

There are several benefits to studying how income-contingent repayment affects labor supply in Australia. First, Australia's repayment system creates large incentives to adjust labor supply at the income threshold above which repayments begin. This is useful because the resulting responses, which are larger than in the United Kingdom, where the incentives are smaller (Britton and Gruber 2020), allow me to identify a rich model of labor supply and study the effects of alternative repayment policies. Second, there is limited scope for selection because there is only one contract available and this contract is subsidized, so most borrowers do not use alternative sources of financing. Finally, loans only cover tuition, implying that borrowers can only adjust their borrowing by changing degree choices. This decision is likely less responsive than the other margins that borrowers in the United States can adjust, such as room and board, and suggests that treating ex ante choices as fixed in my normative analysis may be a reasonable approximation in this setting.

In the first section, I document evidence of moral hazard from income-contingent repayment: borrowers reduce their labor supply to lower repayments on income-contingent loans. I identify this behavioral response by leveraging a 2005 policy change that increased the income threshold above which all borrowers begin loan repayment. Figure I summarizes the effects of this policy change by showing that the income distribution of student debtholders exhibits significant bunching below the repayment threshold, before and after the reform. I present two pieces of evidence that suggest this bunching reflects labor supply responses rather than solely income shifting or tax evasion. First, the bunching is larger in occupations with high hourly flexibility (e.g., restaurant workers) and almost nonexistent in those with low flexibility (e.g., software engineers). Second, using data from Australia's census, I find that borrowers below the repayment threshold work 2%–3% fewer hours (i.e., 1–2 fewer weeks) per year than those above the threshold.

The second part of this article develops a structural model of labor supply that quantitatively replicates the evidence in Figure I. The purpose of the model is to translate this evidence

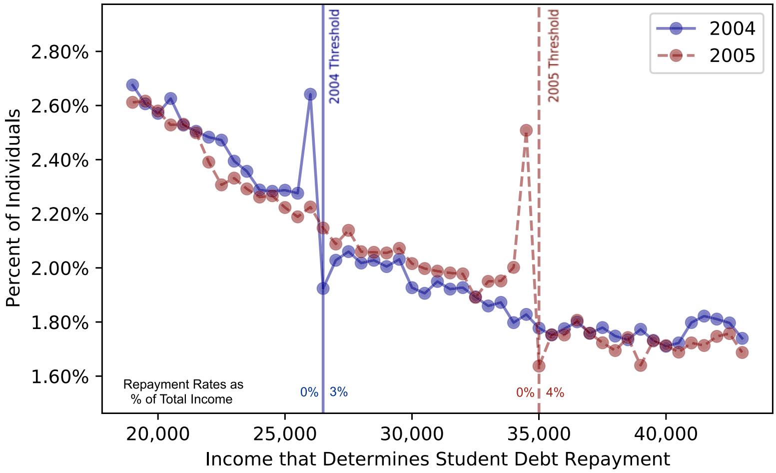

FIGURE I

Income Distribution for Debtholders Around the Income-Contingent Repayment Threshold

This figure shows the distribution of the income that determines repayments on income-contingent loans in 2004 and 2005, before and after the policy change. This income is called HELP income and equals taxable income (i.e., the sum of labor income, capital income, and deductions) plus investment losses, retirement contributions, foreign employment income, and fringe benefits. The vertical lines indicate the thresholds below which borrowers make no repayments and above which they repay 3% and 4% of their income. The sample is all debtholders subject to the criteria in Section II.D. HELP income is deflated to 2005 AU$ using the Consumer Price Index.

into estimates of preference parameters and study the welfare implications of income-contingent repayment. In the model, borrowers choose consumption and labor supply over their life cycles. The two key ingredients are uninsurable income risk and endogenous labor supply, which create a trade-off between the insurance benefits and moral hazard costs of income-contingent repayment.

The unique feature of Australia's income-contingent repayment threshold is that the threshold is a "notch": when borrowers' income crosses it, the fraction of total income repaid increases from 0% to 3%–4%. This contrasts with other systems in the United States, United Kingdom, and Canada, where the threshold changes the marginal repayment rate. Therefore, the evidence in Figure I is inconsistent with a frictionless model, in which no borrowers would locate immediately above the threshold because locating below it delivers more leisure and cash on hand. To explain borrowers locating above the repayment threshold, I introduce a fixed labor supply adjustment cost (Chetty 2012), which could be monetary (e.g., wage reduction) or psychological (e.g., hassle costs). Motivated by the variation in bunching across occupations, I allow this cost to stochastically transition between two different values.

I estimate the model by simulating responses to the policy change in Figure I and find that they are consistent with a moderate labor supply elasticity and substantial optimization frictions. The key parameters that govern labor supply responses—the (Frisch) labor supply elasticity, two fixed costs, and their probabilities—are identified as follows. First, the labor supply elasticity is identified by the bunching below the repayment threshold: a larger elasticity implies more bunching. Second, the number of borrowers above the threshold jointly identifies the lower fixed cost and its probability because individuals with this lower cost are closer to their indifference condition for bunching. I separately identify these two parameters by exploiting panel data: a higher probability of receiving the lower cost implies a larger fraction of people who were bunching before the policy change will also be bunching after the change. Finally, the larger adjustment cost is identified by the distribution of changes in hours worked from survey data. The estimation results show that the evidence in Figure I is quantitatively consistent with a labor supply elasticity of 0.15, fixed adjustment costs of 0.6% and 5% of average earnings, and a 15% probability of receiving the lower cost. Although I study labor supply responses to student loans rather than income taxes or wages, the estimated labor supply elasticity is close to the median of 0.14 from the meta-analyses in Keane (2011) and Chetty et al. (2012).

In the final part of the article, I use the estimated model to study the welfare effect of different repayment contracts. My analysis considers a social planner who maximizes borrower welfare by choosing one contract, holding fixed ex ante choices and the tax system. This perspective speaks to how the loans of existing student debtholders (e.g., the $1.6 trillion of U.S. loans), whose ex ante borrowing and education choices are fixed by definition, should be restructured.

My main normative result is that income-contingent repayment generates meaningful welfare gains relative to fixed repayment. First, I show that the marginal value of public funds of moving from fixed repayment to several existing income-contingent loans ranges from 3.7 to 7.7. These values imply that the welfare gain of income-contingent repayment far exceeds its fiscal cost and are near the 75th percentile for over 100 other policies considered in Hendren and Sprung-Keyser (2020). Next I solve for the income-contingent loan within a two-parameter contract space that maximizes the planner's objective subject to the constraint of raising the same revenue as fixed repayment. The resulting constrained-optimal income-contingent loan increases welfare relative to fixed repayment by the equivalent of a 0.8% increase in lifetime consumption at no additional fiscal cost. Although these gains imply that the moral hazard from income-contingent repayment is small relative to the benefits, it is still important for contract design. Without labor supply responses, the constrained-optimal contract would provide more insurance with a repayment threshold that is over twice as high, doubling its welfare gain relative to fixed repayment.

Income-contingent loans perform well relative to three other methods of providing insurance: (anticipated) loan forgiveness, adding forbearance to fixed-repayment contracts, and equity contracts. First, adding forgiveness after a fixed horizon, as in the United States and United Kingdom, decreases the welfare gains from income-contingent loans. Once income-contingent repayment has been implemented, forgiveness operates as a poorly targeted subsidy by transferring repayment burdens from older to younger, more liquidity-constrained borrowers. Second, a fixed-repayment contract with forbearance, a form of income-contingency that pauses repayments for low-income borrowers, also underperforms the constrained-optimal income-contingent loan. This is because income-contingent loans accelerate repayment from high-income borrowers, enabling them to provide more insurance at a given cost. Finally, equity contracts in which borrowers repay a share of their income for a fixed horizon can outperform income-contingent loans, but only if the horizon is longer than those implemented in practice. However, even with a longer horizon, equity contracts create significantly more redistribution than income-contingent loans because they decouple repayments from debt balances. This large redistribution suggests that equity contracts might cause unmodeled ex ante responses (e.g., additional borrowing) and therefore that income-contingent loans may be a more robust mechanism for implementing income-contingent repayment.

I.A. Related Literature and Contribution

This article is most closely related to the literature on student loans. Friedman (1955) popularized the idea that student loans should be equity-like and advocated using income-sharing agreements. Adverse selection prevents the private provision of these contracts (Herbst and Hendren 2021), but a growing number of governments have moved closer to equity contracts by introducing income-contingent loans (Barr et al. 2019). Britton and Gruber (2020) (BG) study bunching around the repayment threshold in the United Kingdom, which was the second government to introduce income-contingent loans after Australia. Unlike in Australia, the U.K. threshold changes the marginal repayment rate, which is why BG find a small amount of bunching that is consistent with an income elasticity in the static Saez (2010) model of essentially zero. Conversely, the large responses in my setting allow me to estimate a dynamic model of labor supply, which shows that the evidence in Figure I and BG are consistent with a labor supply elasticity of 0.15. The evidence from BG alone does not say whether the lack of bunching in the United Kingdom is driven by a low structural elasticity, the dynamic incentives created by income-contingent repayment, or optimization frictions—each of which has different normative implications.

Theoretical work suggests that income-contingent loans provide a close approximation to Mirrlees (1974)–style optimal human capital policies (Lochner and Monge-Naranjo 2016; Stantcheva 2017), which is supported by two empirical strands of literature on student loans (see Yannelis and Tracey 2022 for a review).[2] The first documents debt overhang created by fixed-repayment contracts, in which reductions in student debt decrease delinquencies and increase income and mobility (Di Maggio, Kalda, and Yao 2021), increase homeownership (Mezza et al. 2020), and change education and occupation choices (Chakrabarti et al. 2020; Folch and Mazzone 2021; Hampole 2022; Murto 2022; Luo and Mongey 2019). The second shows that income-contingent loans can help mitigate these effects, finding reductions in delinquencies (Herbst 2023), mortgage defaults (Mueller and Yannelis 2019), and the pass-through of income to consumption (Gervais,

2. Other government policies toward human capital include subsidies for educational expenses (Bénabou 2002; Bovenberg and Jacobs 2005; Stantcheva 2017) and grants (Abbott et al. 2019; Ebrahimian 2020).

Liu, and Lochner 2022). Quantitative structural models have emphasized the insurance benefits of income-contingent loans (Boutros, Clara, and Gomes 2022), as well as their effects on college enrollment (Matsuda and Mazur 2022), the wage-amenity trade-off (Luo and Mongey 2019), job search (Ji 2021), earnings profiles (Alon, Cox, and Wong 2024), and homeownership (Folch and Mazzone 2021). This study's relative contribution is to provide a model that replicates the labor supply effects of income-contingent repayment and to quantify its effects on optimal contract design. However, the fact that the model is rich enough to quantitatively match my empirical evidence requires it to abstract from these other mechanisms to maintain tractability, most notably education choices.[3]

This article is also part of the large literature on labor supply (see Blundell and MaCurdy 1999 and Keane 2011 for reviews), especially the strand that uses bunching at tax rate discontinuities to identify income elasticities (e.g., Saez 2010; Chetty 2011). Australia's income-contingent repayment threshold is a "notch," meaning it changes the average rather than marginal repayment rate. Notches are useful because they provide an additional moment—the mass of individuals above the threshold—to identify optimization frictions (Kleven and Waseem 2013), such as adjustment costs (Chetty 2012). This article leverages this insight to estimate the first (to my knowledge) dynamic model of labor supply that incorporates both time- and state-dependent adjustment. In addition, the finding that borrowers reduce their labor supply to locate below the income-contingent repayment threshold, which, unlike a tax, increases liquidity more than wealth, connects this literature with evidence that consumption of indebted households responds to liquidity more than wealth (Ganong and Noel 2020).

II. Institutional Background and Data

II.A. *Overview of Australia's HELP*

Australian higher education is primarily financed using government-provided student loans through the HELP, introduced in 1989. This section provides a brief overview of HELP;

3. To the extent that nonpecuniary factors are the main drivers of education choices (as suggested by Patnaik, Wiswall, and Zafar 2020), these results provide a good starting point for optimal contract design more generally.

see Online Appendix A for more detailed discussion. Individuals pursuing undergraduate or graduate degrees can either pay the cost upfront or borrow through HELP. Most individuals choose to do the latter, in which case initial debt equals the tuition of the chosen degree, which averages around US$6,000 a year for undergraduates. Debt balances in subsequent years grow with the CPI net of repayments, implying a zero real interest rate. Individual i's mandatory repayment in year t is

$$\text{HELP Repayment}_{it} = \min\{r_t(y_{it}) \times y_{it}, D_{it}\},$$

where y_{it} denotes HELP income, $r_t(\cdot)$ is the income-dependent repayment rate, D_{it} denotes the beginning-of-year debt balance, and HELP income is the taxable income reported in an individual income tax return plus a few adjustments discussed in Section II.E. Repayment continues either until the remaining balance equals zero or death. This means that HELP effectively forgives debt at the end of working life when borrowers stop generating sufficient income to make compulsory repayments, similar to the forgiveness embedded in U.S. income-driven repayment plans. Partial repayment is common: as of 2004, approximately 25% of debt balances were forecast to be written off (Martin 2004).

II.B. 2004–2005 Policy Change to HELP Repayment Rates

The policy change that I exploit is a 2004–2005 change in $r_t(\cdot)$ that applied to all new and existing debtholders. The left panel of Figure II plots repayment rates as a function of HELP income before the policy change in blue and after the change in red. The most significant change was the movement of the repayment threshold, the point at which borrowers start making repayments, from approximately AU$26,000 to AU$35,000. The median debtholder has HELP income between these thresholds, so this policy change reduced repayments for many borrowers. The right panel of Figure II plots required repayments in AU$, which illustrates that the repayment threshold creates a large incentive to reduce HELP income by generating a discontinuity in the average rather than marginal rate (i.e., it is a “notch,” as in Kleven and Waseem 2013). For a borrower with $35,000 of HELP income in 2005, earning an extra $1 results in a $1,400 larger repayment.

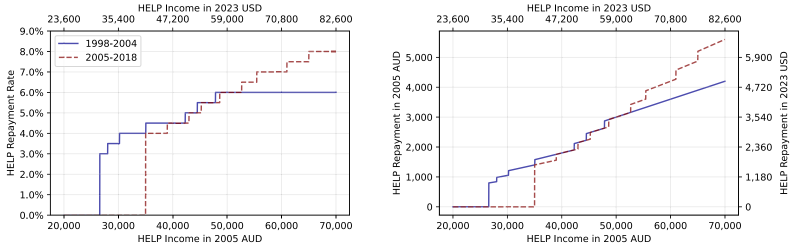

FIGURE II

HELP Repayment Rates as a Function of Income: Before and After the Policy Change

The left panel shows HELP repayment rates as a percentage of HELP income, which are average rather than marginal repayment rates. The right panel shows the required HELP payments implied by the repayment rates on the left, in 2005 Australian dollars on the left axis and 2023 U.S. dollars on the right axis. The blue and red lines correspond to the rates before and after the policy change, respectively. The bottom axis in both panels is HELP income measured in 2005 Australian dollars; the repayment schedule is constant in real terms. The top axis measures HELP income in 2023 U.S. dollars calculated with the AU$/US$ exchange rate from June 2005 and the U.S. CPI inflation rate between June 2005 and January 2023.

II.C. Benefits of Studying Income-Contingent Repayment in Australia

In addition to the presence of administrative data, policy variation, and a repayment function that generates large incentives, there are several other benefits to using HELP to identify labor supply responses to income-contingent repayment relative to the United States. First, there is likely limited selection because HELP is the only government-provided student loan and is subsidized with a zero real interest rate. Consequently, most individuals borrow the maximum amount without alternative financing sources. Second, in response to the policy change, it is unlikely that borrowers will meaningfully increase their HELP debt in anticipation of a lower repayment. Because HELP can only be used to cover tuition, borrowers can only adjust their debt by changing degree choices, which are likely less responsive than the other margins that borrowers in the United States can adjust. Third, HELP is the longest-running government-provided income-contingent repayment program. The fact that this program has been around since 1989 suggests that borrowers understand its incentives. Finally, there are likely limited responses on the supply side because tuition is government-controlled. See Online Appendix A.2 for a detailed discussion of these benefits.

While advantageous for my research question, these differences imply that my results are not immediately generalizable to the United States. Online Appendix A.3 discusses which differences are most likely to influence the effectiveness of income-contingent repayment in the United States.

II.D. Data Sources

I use administrative data from several sources. First, I use individual income tax returns from the Australian Taxation Office (ATO), which contain panel data on income components and basic demographic characteristics. Second, I use HELP data from the ATO that include debt balances, repayments, and a flag for whether individuals acquired new debt balances in a year. Third, I use data on superannuation balances and contributions from the ATO. These three data sets are linked for the universe of Australian taxpayers between 1991 and 2019 in the ATO Longitudinal Information Files[4], known as *ALife*. Starting from the population data set in *ALife*, I restrict attention to individual-year observations for which the individuals (i) are between ages 20 and 64, (ii) are residents in Australia for tax purposes, (iii) are not exempt from HELP repayment due to a Medicare exemption, and (iv) do not have any income from discretionary trusts.[5]

To obtain data on hours worked and housing payments, I use a linkage of these ATO data with the 2016 Census of Population and Housing. This linkage cannot be performed with *ALife* directly, so I instead perform the merge through the Australian Bureau of Statistics Multi-Agency Data Integration Project (MADIP)[6]. The ATO data in MADIP have the same sample coverage as the population-level *ALife* data but a restricted set of variables. Due to data limitations, I use the first three filters from the *ALife* sample to construct a cross-sectional MADIP

4. https://alife-research.app/info/overview.

5. Australia has unit trusts and discretionary trusts, in which beneficiaries have no and full discretion, respectively, over entitlements. Discretionary trusts have been identified as potential sources of tax evasion (Australian Council of Social Service 2017), but *ALife* does not have information on the sources of trust income. I drop these observations to avoid attributing possible tax evasion to labor supply responses.

6. https://www.abs.gov.au/about/data-services/data-integration/integrated-data/multi-agency-data-integration-project-madip.

TABLE I
SUMMARY STATISTICS

	Non-debtholders (1)	Debtholders (2)
Demographic variables		
Age	41.1	29.5
Female	0.46	0.60
Wage-earner	0.85	0.91
Income variables (in 2005 AU$)		
Labor income	35,480	27,136
Capital income	1,221	324
Net deductions	−1,548	−1,099
Taxable income	37,695	27,796
HELP income	38,756	28,586
HELP variables		
HELP debt (in 2005 AU$)	—	10,830
HELP debt at age 26 (in 2005 AU$)	—	13,156
HELP payment (in 2005 AU$)	—	991
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

Notes. This table presents summary statistics from the *ALife* sample from 1991 to 2019, subject to the sample selection criteria discussed in Section II.D. Column (1) uses all individual-years with zero HELP debt; column (2) uses all individual-years with positive HELP debt. The values for all continuous variables represent means. All continuous variables are deflated to 2005 dollars based on the HELP threshold indexation rate. All continuous variables except HELP debt and HELP repayment are winsorized at 2%–98%. HELP Income < 0% threshold corresponds to the mean of a dummy variable for whether HELP income in an individual-year was below the 0% HELP repayment threshold. HELP Income < 0% 2004 threshold and HELP Income < 0% 2005 threshold correspond to means between 1998–2004 and 2005–2018 for whether HELP income in an individual-year was below the HELP repayment threshold, respectively, after the thresholds are adjusted for inflation. Additional details on variable construction are presented in Online Appendix B.1.

sample in 2016, the year in which the census was administered. Finally, I supplement these datasets with the Household, Income and Labour Dynamics in Australia Survey (HILDA)[7], a household survey conducted between 2002 and 2021.

II.E. Summary Statistics

Table I presents summary statistics on the *ALife* sample, the main sample in my analysis, for individuals with and without HELP debt. Relative to non-debtholders, debtholders are younger, less likely to be wage earners (defined as having any self-employment income), and have lower taxable income. The

7. https://melbourneinstitute.unimelb.edu.au/hilda.

most important variable is HELP income, which determines a borrower's HELP repayment rate. HELP income equals taxable income plus several other adjustments, such as adding back reportable superannuation contributions, investment losses, and fringe benefits. These adjustments are not relevant for most individuals: the difference between HELP and taxable income is less than \$100 for over 93% of the observations in 2004. I decompose HELP Income into three terms:

$$\text{HELP Income} = \text{Labor Income} + \text{Capital Income} - \text{Net Deductions}. \tag{1}$$

Labor Income is defined as the sum of salary and wages, tips and allowances, and self-employment income. This represents the largest source of income for most individuals: 95% for debtholders and 91% for non-debtholders. Capital Income is defined as the sum of interest income, dividend income, capital gains, government superannuation, and annuity income, rental income, and trust income. Net Deductions is defined as the residual in equation (1). The Australian tax code allows for various types of deductions, including work-related travel expenses, superannuation contributions, and tax-filing expenses.[8]

The average debt balance among debtholders is AU\$10,800 in 2005 AU\$ (US\$12,800 in 2023 US\$) and AU\$13,200 in 2005 AU\$ among 26-year-old debtholders, which is the age at which most individuals have finished university in Australia. Notably, the 2004–2005 policy change had a large impact on the number of debtholders below the repayment threshold: the fraction below the threshold moved from 51% to 67% after the change.

III. Empirical Evidence of Labor Supply Responses

This section uses the variation in HELP repayment rates from Figure II to characterize how labor supply responds to income-contingent repayment.

8. The available deductions have changed over time, but the current list can be found on the ATO website (https://www.ato.gov.au/individuals-and-families/income-deductions-offsets-and-records/deductions-you-can-claim).

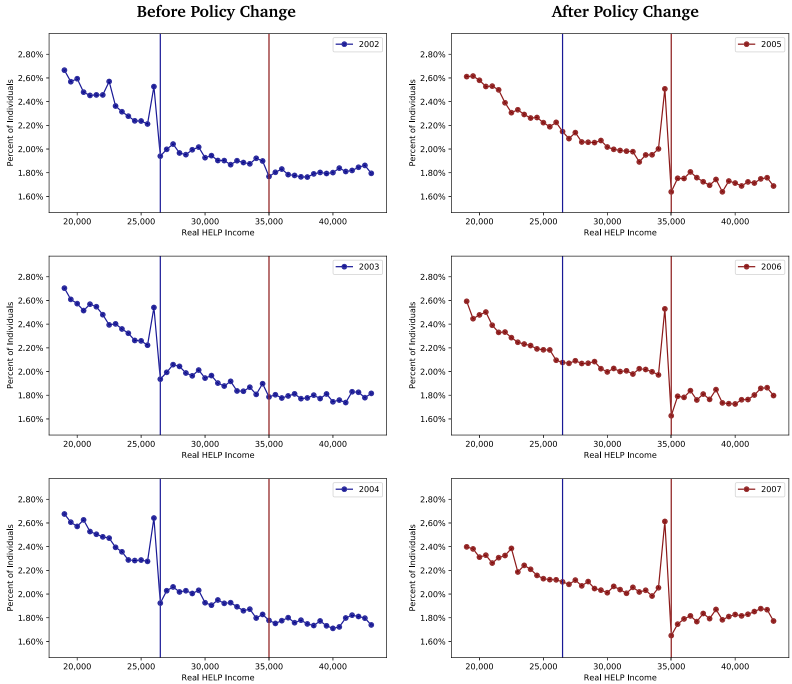

FIGURE III

Income Distribution of HELP Debtholders Around the Repayment Threshold

This figure shows the distribution of real HELP income in Australian dollars, which determines a borrower's repayment rate on her income-contingent loan, in the three years before and after the policy change to the repayment schedule between 2004 and 2005 illustrated in Figure II. Each panel contains a separate year. The vertical lines in the left blue (right red) panel indicate the threshold above which borrowers begin making debt payments of 3% (4%) of their income before (after) the policy change. Each bin represents \$500, and the plot focuses on borrowers within \$8,000 of the two repayment thresholds. The bins are chosen so that they are centered around the 2005 repayment threshold. HELP income is deflated to 2005 Australian dollars using the HELP threshold indexation rate, which is based on the annual CPI. The sample is the *ALife* sample, defined in Section II.D, restricted to people with positive HELP debt balances in each year.

III.A. Bunching of HELP Income Below Repayment Threshold

The first result is the presence of bunching below the repayment threshold. Figure III plots the distribution of HELP income for borrowers with HELP debt in the three years before and after the policy change. HELP income is deflated to 2005 Australian dollars using the HELP threshold indexation rate. The vertical line in each plot corresponds to the HELP repayment threshold in that year, which is constant in real terms across the years in which there is no policy change. These plots focus on borrowers with HELP income within \$8,000 of the two repayment thresholds—around 40% of the entire population of debtholders.

These results show that there is significant bunching below the repayment threshold from 2002 to 2007, but minimal bunching below the smaller thresholds. For the three years before the policy change, shown in the left panels of Figure III, the amount of bunching and shape of the income distribution remain relatively constant. However, the right panels show two changes to the income distribution after the policy change. First, the bunching at the 2004 repayment threshold disappears completely. Second, bunching reappears immediately below the new repayment threshold, providing clear evidence that borrowers adjust their income to reduce income-contingent repayments.

The fact that the bunching in Figure III responds quickly to the policy change shows that it is not driven by mechanical features of Australia's tax system, such as the tendency to report incomes at round numbers. However, a possible threat to identification is the presence of other changes between 2002 and 2007 that affected individuals' incentives to report incomes of certain values. Although it is unlikely that this could explain the evidence in Figure III, given that the bunching is sharp around the repayment threshold, I assess this possibility by examining the income distribution of non-debtholders in Online Appendix Figure IA.III. In contrast to the income distribution of debtholders, this distribution shows no changes around the repayment threshold either before or after the policy change.[9]

III.B. Bunching Increases with Hourly Flexibility

Next I show that the bunching in Figure III is greater in occupations with more hourly flexibility. Using HILDA, I measure the amount of hourly flexibility in each two-digit ANZSCO occupation as the standard deviation of annual changes in log hours worked. This measure is highest for workers in occupations where it is relatively easy to adjust hours, such as hospitality workers (e.g., bartenders) and food preparation assistants (e.g., fast-food workers),

9. There are small changes in the income distribution of non-debtholders at lower values of income, which reflect changes in real terms of the second income tax bracket.

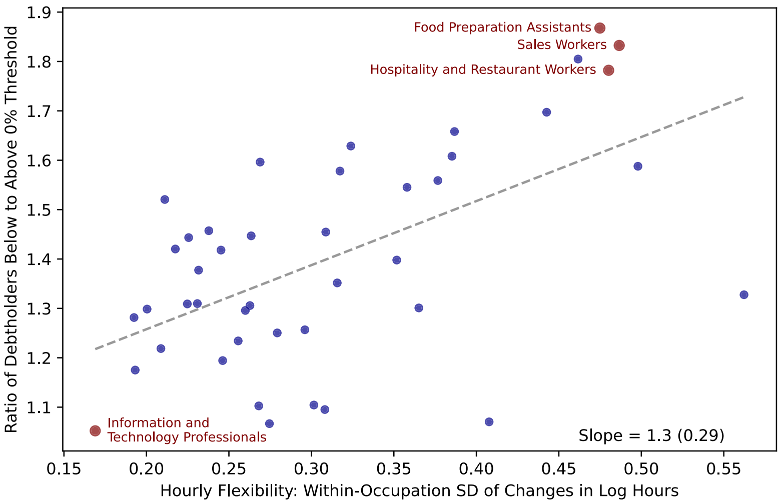

FIGURE IV

Variation in Bunching Across Occupations Based on Hourly Flexibility

This figure plots the relationship between the amount of bunching below the repayment threshold and hourly flexibility by occupation, where each point represents a two-digit ANZSCO occupation. Bunching is measured as the ratio of the number of borrowers in that occupation within \$2,500 below the repayment threshold to the number within \$2,500 above the threshold over 2005 to 2018. Hourly flexibility is measured as the standard deviation of annual changes in log hours worked from HILDA; see Online Appendix Figure IA.V for an alternative measure. The highlighted points correspond to occupations described in the text. The gray dashed line is the regression line, with the estimated slope and standard error reported at bottom right. The sample is the *ALife* sample, defined in Section II.D, restricted to the subset of individual-years for which the individuals are wage earners and have positive HELP debt balances.

and lowest for those where it is more difficult, such as ICT professionals (e.g., software engineers). Online Appendix Table IA.I shows the value of this measure for each occupation.

Figure IV plots the amount of bunching between 2005 and 2018 among wage-earners below the new repayment threshold relative to hourly flexibility. I focus on the period after the policy change because this is when *ALife* offers comprehensive coverage of occupation codes. Each point represents an occupation, and I measure the amount of bunching as the ratio of the number of borrowers in that occupation within \$2,500 below to the number above the threshold so that a ratio of one indicates no bunching (similar to Chetty, Friedman, and Saez 2013). The results show that bunching is more common in occupations with greater hourly flexibility. For example, ICT professionals have the lowest hourly flexibility with a standard deviation of annual changes in log hours of 0.17. In this occupation, there are only 5% more borrowers below than above the threshold. In contrast, hospitality workers have almost three times more hourly flexibility and exhibit significantly more bunching, with 80% more borrowers below than above the threshold. Quantitatively, Online Appendix Table IA.II shows that hourly flexibility explains 34% of the variation in bunching across occupations.

One concern with the evidence in Figure IV is that hourly flexibility might be correlated with tax evasion or income-shifting across occupations. To assess the importance of evasion, I calculate the share of workers in each occupation that receives labor income from allowances, tips, director's fees, consulting fees, or bonuses. This variable is a proxy for tax evasion because it is easier to misreport these other sources of income relative to salary and wages (Paetzold and Winner 2016; Slemrod 2019). Online Appendix Figure IA.VI shows that this measure, unlike hourly flexibility, exhibits little correlation with the amount of bunching.

III.C. Borrowers Below the Repayment Threshold Work Fewer Hours

A second piece of evidence that suggests that the bunching in Figure III reflects, at least partly, labor supply responses is that borrowers below the repayment threshold work fewer hours. I measure hours worked using a question in the 2016 census in which individuals report the number of hours worked during the week before the census night. Figure V plots the average hours worked in \$250 bins of HELP income around the repayment threshold in census year 2016, in addition to the income distribution (the solid red line). I find that borrowers locating immediately below the threshold work on average 1 hour less per week than those immediately above it, which is 2.6% of the standard 38-hour workweek in Australia.[10] This adjustment occurs within a borrower's current occupation: Online Appendix Figure IA.VII finds little evidence that those below the repayment threshold are more likely to have switched occupations.

10. These results are not driven by a group of borrowers outside the labor force: Online Appendix Figure IA.IX shows that the patterns are nearly identical in the sample of borrowers earning positive labor income.

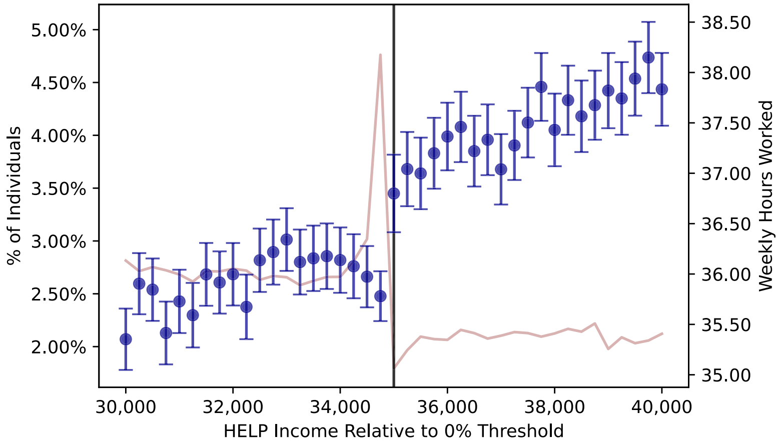

FIGURE V

Self-Reported Hours Worked Around the Repayment Threshold

This figure plots the 2016 HELP income distribution as the solid red line (measured on the left axis). HELP income is deflated to 2005 with the HELP threshold indexation rate, which is based on the annual CPI. Each bin represents $250, and the bins are chosen so that they are centered around the 2005 repayment threshold. The blue points present the average value of individuals' reported hours worked from the 2016 Census of Population and Housing in each bin, along with 95% confidence intervals. The sample is the cross-sectional MADIP sample described in Section II.D, restricted to individuals with positive HELP debt balances.

The results in Figure V are subject to two caveats. First, as discussed in Section II.D, the MADIP and *ALife* samples differ slightly. To mitigate concerns about sample selection, Online Appendix Figure IA.X shows that the distribution of HELP income in 2016 across the two samples is quantitatively similar. Second, these data on hours worked are self-reported by employees, which introduces concerns about reporting issues. For this reason, I do not target this evidence directly when estimating the structural model.

III.D. Bunching Decreases with the Probability of Repayment

Next I show that the amount of bunching below the repayment threshold increases with debt balances. To measure the amount of bunching, I construct a bunching statistic following the literature that uses discontinuities in tax rates to estimate income elasticities. First, I split borrowers into groups based on their ages and debt balances. I split ages into five-year bins, which gives a similar number of observations within each bin, and then split debt balances at their median value in each age and year. Second, in each group, I fit a five-piece spline to the income distribution in that group, leaving out the region $\mathcal{R} = [\$32{,}500, \$35{,}000 + X]$. The choice of \$32,500 represents a conservative estimate of where the bunching begins, and X is a constant intended to reach the upper bound at which the income distribution is affected by the threshold. This spline corresponds to an estimate of the counterfactual income distribution absent the bunching induced by the threshold. Third, I iterate on X so that this counterfactual density integrates to one. Finally, I compute the bunching statistic, b, as:

$$b = \frac{\text{observed density in } \mathcal{R}}{\text{counterfactual density in } \mathcal{R}} - 1. \quad (2)$$

This bunching statistic is an estimate of the excess number of borrowers below the threshold relative to a counterfactual distribution in which it did not exist.[11]

Figure VI shows the value of the estimated b across the different groups of borrowers. The results show two patterns. First, for all age groups, the estimated value of b is higher among borrowers with above-median debt balances. This finding suggests that the probability of eventual repayment is an important determinant of labor supply responses. The second pattern is that the amount of bunching decreases moderately with age: the estimated b is 22%–33% lower among borrowers above 40 than those below 25. This finding suggests that liquidity constraints, which are tightest among young borrowers, might be important.

The amount of bunching below the repayment threshold also varies based on the properties of occupation-specific wage profiles. These wage profiles are plotted in Online Appendix Figure IA.VIII, which shows that there are some occupations in which the average individual will almost certainly earn enough income to pay her debt, whereas there are others in which the average individual spends her entire life below the repayment threshold. Online Appendix Table IA.II shows that the amount of bunching is larger in occupations with flatter income profiles and lower maximum incomes, both of which support the idea that a lower

11. This statistic is a standard measure in the literature on bunching (e.g., Chetty 2011), but Online Appendix Figure IA.XI shows that the qualitative patterns in Figure VI hold using a simpler measure of bunching.

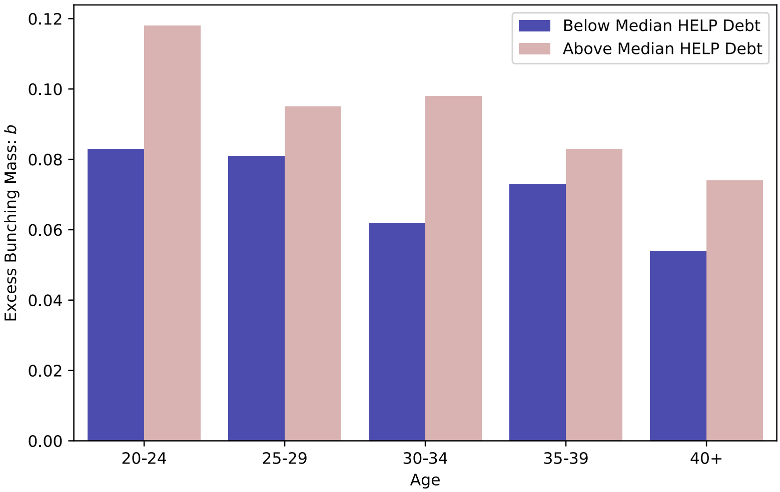

FIGURE VI

Variation in Bunching by Debt Balances and Age

This figure plots the bunching statistic defined in equation (2) computed for different samples of debtholders based on age and debt balances. The age groups are listed on the horizontal axis. In each age group, the blue (red) bars plot the estimated statistic for borrowers with below-median (above-median) debt balances, where the median is calculated separately for each year and age group. The calculation of b is detailed in Online Appendix B.2. Standard errors are omitted from this plot because the corresponding 95% confidence intervals overlap visually in the units of this plot. The sample is the *ALife* sample, defined in Section II.D for the period between 2005 and 2018 after the policy change, restricted to individuals with positive HELP debt balances.

probability of eventual repayment increases borrowers' willingness to reduce their labor supply.

III.E. Bunching Decreases with Proxies for Liquidity

Because repayment ceases after debt balances are paid off, unlike a tax, locating below the repayment threshold increases liquidity but has a smaller effect on wealth. Therefore, the evidence that borrowers reduce their labor supply to locate below the repayment threshold echoes the conclusion of Ganong and Noel (2020) that current budget constraints are important for understanding the behavior of indebted households. Without direct measures of liquidity, I use several complementary measures to more directly assess its importance.

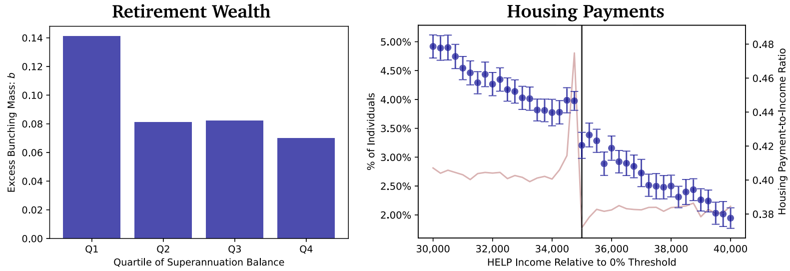

FIGURE VII

Bunching and Proxies for Liquidity Constraints

Notes: The left panel of this figure plots the bunching statistic defined in (2) computed for different samples of debtholders based on quartiles of superannuation balances computed in each year. The calculation of b is detailed in Online Appendix B.2. Standard errors are omitted because the corresponding 95% confidence intervals overlap visually in the units of this plot. The sample is the *ALife* sample defined in Section II.D between 2005 and 2018 after the policy change, restricted to individuals with positive HELP debt balances. The right panel replicates Figure V but plots the average housing payment-to-income ratios instead of hours worked within each bin. Housing payments are defined as combined mortgage and rent payments from the 2016 census. Error bars represent 95% confidence intervals.

First, I find that there is more bunching among borrowers who reveal a preference for liquidity by holding less retirement wealth. The largest form of retirement savings in Australia is called superannuation ("super"), which is the second-largest source of household wealth (Australian Council of Social Service 2018); contributions have generally been tax-advantaged to incentivize saving. Therefore, super balances are a natural proxy for liquidity based on revealed preference: borrowers who are unwilling to contribute to a tax-advantaged but illiquid account are implicitly revealing a high valuation of liquidity (Coyne, Fadlon, and Porzio 2022). The left panel of Figure VII plots the bunching statistic based on quartiles of super balances from *ALife* that are defined within each year. The amount of bunching is highest for borrowers in the bottom quartile, approximately twice as large as the top quartile. Second, borrowers below the repayment threshold have larger housing payments. For most individuals, housing payments represent one of the largest sources of liquidity demand. Therefore, if liquidity influences labor supply responses, borrowers below the repayment threshold should have larger housing payments. The right panel of Figure VII shows that this prediction holds in the data: borrowers below the repayment threshold have larger housing payment-to-income ratios by approximately 2 percentage points.

III.F. Additional Results and Discussion

1. *Evasion.* An obvious explanation for the bunching in Figure III is evasion, in which borrowers misreport their incomes. Although this is illegal, Online Appendix B.3 discusses several facts, in addition to the direct evidence of a labor supply response in Figure V, that suggest it cannot explain all of the responses. Nevertheless, it is likely that some of the responses do reflect evasion, which would affect my normative results in one of two ways. First, if the costs of evasion are entirely real resource costs, then whether the responses in HELP income reflect labor supply or evasion is irrelevant as long as the model can replicate them (Feldstein 1999). However, in the more likely case that some of the costs of evasion are transfers to other agents or the government (e.g., fines), my model will overstate the welfare costs of the moral hazard created by income-contingent repayment (Chetty 2009; Gorodnichenko, Martinez-Vazquez, and Peter 2009), reinforcing my qualitative conclusions.

2. *Other Demographic Heterogeneity.* Online Appendix Table IA.III examines heterogeneity in bunching based on the remaining demographic characteristics in the data. The results show few differences by gender, 5% less bunching among borrowers with a spouse, and 12% less bunching among borrowers with dependents. Although the first result contrasts with existing evidence that female labor supply is more elastic, an important caveat is that the responses that I estimate are local to the repayment threshold and thus do not capture extensive-margin responses, which often drive the larger responses among women (Saez, Slemrod, and Giertz 2012).

IV. Life Cycle Model

The empirical results in Section III leave open two important questions. First, how large are these responses quantitatively? Second, are these responses large enough to imply that the moral hazard created by income-contingent repayment outweighs the insurance benefits? This section presents and estimates a structural model designed to answer these questions. The key ingredients in the model are moral hazard from endogenous labor supply, a demand for insurance from the combination of uninsurable income risk and borrowing constraints, and optimization frictions.

IV.A. Model Description

1. *Demographics.* Time is discrete, and each period, t, corresponds to one calendar year. At $t = h \in \{\underline{h}, \underline{h}+1, ..., \overline{h}\}$, a cohort h of individuals indexed by i is born at age a_0. The number of individuals is discrete and denoted by N, with a fraction μ_h born in cohort h. The initial age, a_0, should be interpreted as the age at which individuals exit college and enter the labor force. The age of an individual i in cohort h at time t is $a_{ht} = a_0 + t - h$. Before age a_T, individuals face age-dependent mortality risk, with the survival probability at age $a+1$ conditional on survival at age a denoted by m_a. Between ages a_0 and $a_R - 1$, individuals are in their working life and can supply labor to earn income. At age a_R, individuals transition to retirement and cannot supply labor; after age a_T, individuals die with probability one.

2. *Preferences.* During working life, individuals choose consumption, c, and labor supply, ℓ. An individual i at age a has preferences over consumption and labor supply that are time-separable with discount factor β and expected utility with flow utility equal to:

$$\mathcal{U}_a(c_{ia}, \ell_{ia}) = \frac{n_a}{1-\gamma}\left(\frac{c_{ia}}{n_a} - \kappa\frac{\ell_{ia}^{1+\phi^{-1}}}{1+\phi^{-1}}\right)^{1-\gamma}. \tag{3}$$

In equation (3), γ is the coefficient of relative risk aversion (and the inverse elasticity of intertemporal substitution, EIS), ϕ is the Frisch labor supply elasticity, and κ is a scaling parameter. The nonseparability within period follows Greenwood, Hercowitz, and Huffman (1988) and eliminates wealth effects on labor supply, meaning that the marginal rate of substitution between c and ℓ is independent of c. This is consistent with empirical evidence that finds small labor supply responses to changes in wealth (Keane 2011; Cesarini et al. 2017; Gyöngyösi, Rariga, and Verner 2022). n_a is an equivalence scale that captures the evolution of household size over the life cycle (Lusardi, Michaud, and Mitchell 2017).

3. *Labor Income Process.* During working life, the labor income of individual i at age a, y_{ia}, is equal to the product of the individual's wage rate, w_{ia}, and labor supply, ℓ_{ia}. Wage rates are modeled in partial equilibrium and consist of three components:

$$\log w_{ia} = g_{ia} + \theta_{ia} + \epsilon_{ia}. \tag{4}$$

The first component, g_{ia}, is a deterministic life cycle component discussed below. The other two components are stochastic and evolve as follows:

$$\begin{aligned} &\theta_{ia} = \rho\theta_{ia-1} + \nu_{ia}, \quad \theta_{ia_0} = \delta_i, \quad \delta_i \sim \mathcal{N}(0, \sigma_i^2), \\ &\nu_{ia} \sim \mathcal{N}(0, \sigma_\nu^2), \quad \epsilon_{ia} \sim \mathcal{N}(0, \sigma_\epsilon^2). \end{aligned} \tag{5}$$

This wage process incorporates permanent and transitory shocks. The transitory component, ϵ_{ia}, is i.i.d. within and across individuals. The permanent component, θ_{ia}, depends on permanent shocks, ν_{ia}, which have persistence ρ, and an individual fixed effect, δ_i, which captures ex ante heterogeneity across individuals. This wage process is similar to the income processes used in canonical life cycle models (Gourinchas and Parker 2002).

4. *Education.* Individuals differ ex ante based on their education levels, $\mathcal{E}_i \in \{0, 1\}$, where

$$\mathcal{E}_i \sim \text{Bernoulli}(p_E). \tag{6}$$

$\mathcal{E}_i$ determines the deterministic component of wages, g_{ia}, which takes the following form:

$$g_{ia} = \delta_0 + \delta_1 a + \delta_2 a^2 + \mathcal{E}_i\left(\delta_0^E + \delta_1^E a\right). \tag{7}$$

This specification captures that the returns to experience are quadratic (in logs), as in Mincer (1974), and that borrowers may have different wage levels and profiles. Although education levels and borrowing (described below) are exogenous, heterogeneity in education levels is included in the model for two reasons. First, when I compare changing the structure of debt repayment contracts to changing the tax and transfer system, I need to account for the fact that the former only affects the college-educated, whereas the latter affects everyone. Second, the *ALife* panel is not long enough to separately identify the income process of the college educated from the rest of the population.

5. *Optimization Frictions.* Individuals choose their labor supply at the same time that they choose consumption, after all

shocks are realized. The evidence in Figure III rejects a model in which labor supply is determined solely by the disutility of work and the benefits of higher income. Since utility increases in consumption and leisure, such a model cannot generate any borrowers immediately above the threshold because locating below it gives more consumption and leisure. Therefore, some type of adjustment friction is needed to generate borrowers above the repayment threshold. I introduce a fixed cost, f_{ia}, of choosing labor supply in the current period that is different from that in the past period, $\ell_{ia} \neq \ell_{ia-1}$, paid in utils (Masatlioglu and Ok 2005). As in the CalvoPlus model of Nakamura and Steinsson (2010), this fixed cost is stochastic and evolves according to:

$$f_{ia} = \left[\omega_{ia} f_L + (1-\omega_{ia}) f_H\right] \mathbf{1}_{a>a_0}, \quad \omega_{ia} \sim \text{Bernoulli}(\lambda),$$
$$f_L < f_H. \tag{8}$$

Equation (8) allows the fixed cost to vary between two values, f_L and f_H, with probabilities λ and $1-\lambda$, respectively. This specification nests two canonical models of imperfect adjustment. When $f_L = 0$ and $f_H = \infty$, it collapses to a Calvo (1983) model, which has been used in household finance to model mortgage refinancing (Berger et al. 2021). In contrast, when $\lambda = 1$, it corresponds to an (S, s) model, which has been used to model portfolio choice (Abel, Eberly, and Panageas 2013), saving decisions (Choukhmane 2021), price setting (Caplin and Spulber 1987), capital investment (Caballero and Engel 1999), and health insurance (Handel 2013).

Modeling labor supply adjustment frictions using a stochastic fixed cost is reduced form and warrants discussion. This choice is motivated by the evidence in Figure IV, which shows variation across occupations in labor supply responses. Equation (8) is designed to capture this by allowing individuals to be in one of two “occupations” with different adjustment costs. However, the analogy between the different values of f_{ia} and occupations is incomplete in that f_{ia} is not associated with different wage processes. This restriction is made for tractability: allowing heterogeneity in wage profiles would make estimation infeasible because the wage process has to be estimated jointly, as described in Section IV.C.

Ideally, the data would allow me to identify a more microfounded model of adjustment frictions. Since this is not possible, my approach is to instead consider a reduced-form specification that allows for the two canonical types of imperfect adjustment, similar to Andersen et al. (2020). State-dependent adjustment comes from the fixed costs that generate (S, s)–type behavior, in which individuals only adjust their labor supply when the benefits of adjustment are sufficiently high. Economically, these costs could capture real costs associated with changing labor supply, such as wage reductions, or psychological costs, such as the hassle costs of adjusting a work schedule or search costs associated with changing jobs when hours are constrained by firms. However, adjustment in this model is also time-dependent in the sense that it depends on the realization of ω_{ia}. Economically, this can capture frictions on the demand-side of the labor market that result in the slow arrival of opportunities to adjust labor supply, as in models of job search à la Diamond-Mortensen-Pissarides or job transitions à la Kleven et al. (2023).

The key concern with this reduced-form approach to modeling adjustment frictions is that the values of f_L, f_H, and λ that I estimate might not be policy invariant when I study counterfactual repayment contracts. To address this concern, I explore how much these parameters would have to change to overturn the qualitative results from my counterfactuals. However, the use of within-individual variation on a policy change that did occur in the data to estimate the model makes it more likely that the estimated parameters would be stable in the counterfactuals that I consider.

6. *Liquid Assets.* At age a_0, individuals begin with a stock of liquid assets, A_{ia_0}, where

$$A_{ia_0} \sim \begin{cases} 0, & \text{with probability } p_A(\mathcal{E}_i), \\ \text{Log-normal}\left(\mu_A(\mathcal{E}_i), \sigma_A(\mathcal{E}_i)^2\right), & \text{with probability } 1 - p_A(\mathcal{E}_i). \end{cases} \tag{9}$$

The dependence of this distribution on $\mathcal{E}_i$ allows for the possibility that initial liquidity varies with education levels. In later periods, liquid-asset balances at the end of the period at age $a-1$ are denoted by A_{ia}. Positive balances in liquid assets pay a gross return of R. Individuals can also borrow using unsecured credit up to an age-dependent borrowing limit, $\underline{A}_a$. The interest rate on borrowing is $R + \tau_b$, where τ_b captures the borrowing-rate wedge. Asset income, i_{ia}, is received prior to consumption at age a and is equal to:

$$i_{ia} = r(A_{ia}) \times A_{ia}, \quad r(A_{ia}) = R - 1 + \tau_b \times \mathbf{1}_{A_{ia}<0}. \tag{10}$$

Both interest rates are taken as exogenous for tractability. This is unlikely to quantitatively affect the results because individuals with large debt balances, who are most affected by the policy changes that I consider, are young and hold a small share of aggregate wealth.

7. *Student Debt.* At age a_0, individuals are also endowed with debt balances, D_{ia_0}, where

$$D_{ia_0} = \mathbf{1}_{\mathcal{E}_i=1} \times \tilde{D}, \quad \tilde{D} \sim \text{Log-normal}\left(\mu_d, \sigma_d^2\right). \tag{11}$$

In subsequent periods, debt balances evolve according to:

$$D_{ia+1} = (1 + r_d)D_{ia} - d_{ia}, \quad d_{ia} = d(y_{ia}, i_{ia}, D_{ia}, a, t), \tag{12}$$

where r_d is the (net) interest rate on student debt and d_{ia} is the required debt payment determined by the repayment function, $d(\cdot)$. This function depends on borrowers' income and debt balances; any outstanding debt is discharged at $a = a_R$ or upon death.

8. *Government.* A government earns revenue from progressive taxes on labor and asset income, $\tau_{ia} = \tau(y_{ia}, i_{ia}, t)$, and debt repayments. Expenditures include new debt, D_{ia_0}, means-tested unemployment benefits, $ui_{ia} = ui(y_{ia}, i_{ia}, A_{ia})$, and a means-tested retirement pension, $\bar{y}_R(A_{ia})$. The government also pays a net consumption floor, $\underline{c}_{ia}$, to ensure that consumption exceeds zero. There is no deduction for interest paid on unsecured borrowing.

9. *Model Solution.* Individuals solve a dynamic programming problem with nine states and two controls. The full recursive decision problem is presented in Online Appendix D.1; the model is solved using numerical dynamic programming techniques described in Online Appendix D.2.

IV.B. Calibrated Parameters

Table II shows the values of parameters that are calibrated directly using observed data, formulas from the Australian tax and transfer system, or prior literature. I provide a brief description of this calibration; see Online Appendix D.3 for additional details.

1. *Demographics.* Individuals are born at age 22, retire at 65, and die with certainty after 89. Prior to age 89, mortality risk is calibrated using Australia's life tables. Cohort-specific birth rates are calibrated to match the fraction of 22-year-olds by year

TABLE II
VALUES OF CALIBRATED MODEL PARAMETERS

Description	Parameter(s)	Values/targets
Demographics		
Ages	$\{a_0, a_R, a_T\}$	{22, 65, 89}
Mortality rates	$\{m_a\}$	APA life tables
First and last cohorts	$\underline{h}, \overline{h}$	1963, 2019
Cohort birth probabilities	$\{\mu_h\}$	*ALife*
Equivalence scale	$\{n_a\}$	HILDA household size
Number of distinct individuals	N	1,600,000
Year of simulated policy change	T^*	2005
Assets		
Real interest rate	$R-1$	1.84%
Unsecured borrowing wedge and limit	τ_b, $\{\underline{A}_a\}$	14.6%, HILDA credit card limit
Probabilities of zero initial assets	$p_A(1)$, $p_A(0)$	0.197, 0.350
Distribution for $\log A_{ia_0}$	$\mu_A(1)$, $\mu_A(0)$,	7.42, 6.79
	$\sigma_A(1)$, $\sigma_A(0)$	1.72, 2.64
Student debt		
Fraction of borrowers	p_E	0.308
Real interest rate on debt balances	r_d	0%
Distribution for $\log D_{ia_0}$	μ_d, σ_d	9.40, 0.86
Debt repayment function	$d(\cdot)$	HELP 2004 at $t < T^*$, HELP 2005 at $t \geqslant T^*$
Government		
Income and capital taxes	$\tau(\cdot)$	ATO income tax formulas
Unemployment benefits	$ui(\cdot)$	ATO Newstart Allowance
Retirement pension	$\bar{y}_R(\cdot)$	ATO age pension
Net consumption floor	$\underline{c}$	\$40
Preference parameters		
Relative risk aversion	γ	2.23

Notes. This table shows the parameters that are calibrated in a first stage. See Online Appendix D.3 for additional details.

in *ALife*. I use data on household sizes from HILDA to compute equivalence scales, as in Lusardi, Michaud, and Mitchell (2017).

2. *Interest Rates and Borrowing.* There is no inflation in the model, and the numeraire is equal to AU\$1 in 2005. When compared to the model, all empirical values are deflated to 2005 AU\$ using the HELP threshold indexation rate. The real interest rate is set to 1.84%, the (geometric) average deposit rate between 1991 and 2019 in Australia. The unsecured borrowing rate is set based on average credit card borrowing rates, and age-specific borrow-

ing limits are set based on credit card limits in HILDA. The real interest rate on student debt is set to zero following HELP.

3. *Initial Conditions.* The distribution of initial assets is calibrated to match the liquid-wealth distribution of individuals between ages 18 and 22. The fraction of borrowers, p_E, is equal to the fraction of 22-year-old individuals in *ALife* with positive debt. The distribution of initial debt is set based on the distribution among borrowers younger than age 26 in *ALife*, the age by which most people have finished their undergraduate studies.

4. *Government Taxes and Transfers.* Income and capital taxes are set to match the individual income tax schedules provided by the ATO in 2004 and 2005. Unemployment benefits and the retirement pension are set to match their counterparts in Australia. The latter is means-tested based on assets and income.

5. *Preference Parameters.* The preference parameter that I do not estimate due to a lack of identifying variation is the coefficient of relative risk aversion (RRA). I choose to set $\gamma = 2.23$ based on Choukhmane and de Silva (forthcoming). In an extension, I consider the effects of changing γ and the EIS independently using recursive Epstein-Zin preferences, which introduce a preference for the timing of the resolution of uncertainty.

IV.C. Simulated Minimum Distance Estimation

I estimate the remaining 15 parameters, denoted by Θ, using simulated minimum distance (SMD). These parameters can be divided into three groups: preference parameters; parameters governing the age profile of wages, g_{ia}; and parameters governing shocks to the wage process. In contrast to the standard approach (e.g., Gourinchas and Parker 2002), I cannot estimate the latter two sets of parameters separately in a first stage because the income process is endogenous. I thus proceed by combining a standard set of estimation targets used to identify the latter two sets of parameters in models with exogenous income with the quasi-experimental variation from the HELP policy change.

1. *Simulated Policy Change.* I replicate the policy change in Figure II in the model by solving the model for two specifications of the student debt repayment function, $d(\cdot)$: the HELP 2004

schedule and the HELP 2005 schedule. Starting at $t = \underline{h} = 1963$, I simulate cohorts of individuals making choices under the 2004 schedule. At $t = T^* = 2005$, I then conduct a one-time unanticipated policy change in which all existing debtholders born at $t < T^*$ and subsequent debtholders start repaying under the 2005 schedule.

2. *Estimator.* I estimate Θ using SMD, which consists of choosing a set of estimation targets and a weighting matrix. Denote the empirical values of the estimation targets as $\hat{m}$, the vector of the estimation targets estimated in the model via simulation as $m(\Theta)$, and the weighting matrix as $W(\Theta)$. The estimate of Θ is then defined as Θ^*, where

$$\Theta^* = \arg\min_{\Theta} \left(\hat{m} - m(\Theta)\right)' W(\Theta) \left(\hat{m} - m(\Theta)\right).$$

I choose $W(\Theta)$ so the objective function is the sum of squared arcsin deviations between $\hat{m}$ and $m(\Theta)$. The 44 estimation targets are detailed in Online Appendix D.4 and discussed below.

IV.D. Choice of Estimation Targets and Parameter Identification

This section discusses the identification of parameters in the SMD estimation. All parameters are jointly identified, but I choose the set of estimation targets so that each one is most sensitive to a subset of parameters. The discussion is qualitative; Online Appendix Table IA.IV provides the elasticities of estimation targets with respect to parameters that support this discussion.

1. *Labor Supply Elasticity, ϕ.* The labor supply elasticity is primarily identified by bunching in the HELP income distribution below the repayment thresholds before and after the policy change: a larger elasticity implies greater mass below these thresholds. To characterize this bunching, I use the distributions of HELP income among debtholders three years before and three years after the change. I pool distributions to minimize simulation error; Section IV.F examines the model's fit in the two years surrounding the change.

2. *Lower Adjustment Cost, f_L.* The lower adjustment cost is primarily identified by the mass of the income distribution above the repayment threshold. Since $f_L < f_H$, individuals that

are marginal with respect to bunching below the threshold are more likely to have $f_{ia} = f_L$. Therefore, a larger f_L increases the mass above the threshold.

3. *Adjustment-Cost Probability, λ.* Based on the income distribution alone, the probability of individuals receiving the lower adjustment cost, λ, is not separately identified from the cost itself, f_L. To separate these parameters, I exploit a target based on panel data: the probability of bunching in 2005 below the new repayment threshold conditional on bunching in 2004 below the old repayment threshold.[12] Because bunching in two subsequent periods is mostly concentrated among borrowers that have $f_{ia} = f_L$ in both periods, the persistence of bunching below the threshold is increasing in λ.

4. *Upper Adjustment Cost, f_H.* Identifying the upper adjustment cost, f_H, is more challenging because individuals with $f_{ia} = f_H$ are further from their indifference condition for bunching below the repayment threshold. Therefore, to identify this parameter, I need to exploit information on labor supply adjustments made for other reasons. In the model, these other adjustments are primarily due to wage fluctuations. To capture the distribution of these adjustments, I target the kurtosis of changes in (log) hours worked in the data and $\log \ell_{ia}$ in the model. Kurtosis—a scale-free measure describing the peakedness of a distribution—is increasing in f_H because a higher value of f_H implies longer gaps between adjustments and hence a larger difference between the current and desired ℓ_{ia}.[13] To measure the kurtosis of changes in hours worked, I use HILDA, which has the downside of being a survey but is the only available source of panel data on hours worked. Therefore, I follow Heathcote, Storesletten, and Violante (2014) and allow for measurement error in hours worked, which is multiplicative in levels and normally distributed with mean one and variance ι^2. To identify ι, I add as an estimation target the probability of zero adjustment in hours worked.

12. I'm grateful to an anonymous referee for suggesting this identification strategy.

13. Kurtosis is also used to capture selection into adjustment in models of price setting (Alvarez, Le Bihan, and Lippi 2016).

5. *Time Discount Factor, β.* To identify the time discount factor, I leverage the dynamic incentives created by an income-contingent loan. An income-contingent loan differs from a tax because reducing payments today leads to higher future payments when the debt is repaid. These dynamic incentives are larger for individuals with less debt, for whom the probability of repayment is higher. The extent to which individuals respond to these future incentives depends on their time preferences, which are controlled (partially) by β.[14] Therefore, I identify β by targeting heterogeneity in bunching by debt balances, where bunching is measured using the ratio of borrowers below to above the 2005 threshold after the policy change. I measure heterogeneity by taking the ratio of this measure for individuals in the top and bottom quartiles of debt balances within each year.

6. *Scaling Parameter, κ.* This parameter is identified by the average value of ℓ_{ia}. A higher value increases the disutility of labor supply and thus lowers average values of ℓ_{ia}.

7. *Wage Profile Parameters, δ_0, δ_1, δ_2, δ_0^E, and δ_1^E.* These parameters are primarily identified by the regressions of log income onto polynomials in age and an education-level indicator. If labor supply were exogenous, they could be estimated separately with these estimation targets alone. With endogenous labor supply, these parameters control the wage rather than the income process and must be estimated jointly.

8. *Wage Risk Parameters, ρ, σ_ν, σ_ϵ, and σ_i.* These parameters are identified by how the cross-sectional variance of log income varies with age and the percentiles of income growth at one-year and five-year horizons. This set of moments is standard in the literature used to estimate exogenous income processes (e.g., Guvenen, McKay, and Ryan 2022), and the identification is similar here even though the income process is endogenous. The cross-sectional variance at age 22 identifies σ_i, the variance

14. To see this intuition more formally, consider a two-period model where borrowers have linear utility, discount at rate $\beta = \frac{1}{1+r}$, and have a probability of repayment p in the second period. The value of locating below the 2005 repayment threshold is then $\$1,400 \times \beta \times \left(\beta^{-1} - p\right)$. Differentiating with respect to p shows that this value depends on p if and only if $\beta \neq 0$, and increases in sensitivity to p as β increases.

of the initial permanent income. The extent to which the cross-sectional variance increases with age identifies the persistence of income shocks, ρ: more persistent shocks generate a greater increase in variance over the life cycle (Deaton and Paxson 1994). The sum of the variances of permanent and transitory income shocks, σ_ν and σ_ϵ, is identified by the level of this cross-sectional variance at later ages. These two variances are then separated using the percentiles of income growth: a larger variance of permanent shocks, σ_ν, delivers fatter tails in five-year than in one-year income growth.

IV.E. Estimation Results and Model Fit

Table III shows the results from estimating five different models, where the final column corresponds to the baseline model. Column (1) starts by estimating a model without labor supply adjustment frictions. This model does not generate any individuals locating above the repayment threshold and delivers an unrealistically low estimate of the (Frisch) labor supply elasticity of $\phi = 0.003$. Column (2) estimates a model with a constant fixed adjustment cost, corresponding to a standard (S, s) model. Column (3) allows the adjustment cost to be either zero or infinity à la Calvo (1983), while column (4) combines this with column (2) by allowing $f_L > 0$. This estimation attributes the lack of adjustment by individuals above the repayment threshold mostly to the adjustment cost shock, given the estimated value of λ is similar to that in column (3). This finding implies that labor supply adjustment appears to be more time- rather than state-dependent, similar to the findings of Andersen et al. (2020) in the context of mortgage refinancing.

The results for the baseline model are reported in column (5). The estimate of the labor supply elasticity is 0.15. Online Appendix E shows this estimate is close to the median value of 0.14 for Frisch and Hicksian intensive-margin elasticities reported in Keane (2011) and Chetty et al. (2012), and further discusses how my results relate to existing literature. The estimated fixed costs are $f_L = \$378$ and $f_H = \$3{,}191$, approximately 0.6% and 5% of average income. Given the estimate of $\lambda = 0.15$, individuals receive the lower adjustment cost that allows them to adjust their labor supply more cheaply every 6–7 years. Comparing columns (4) and (5) shows that allowing $f_H < \infty$ does not have a major effect on other estimated parameters. This is because f_H is

TABLE III

SIMULATED MINIMUM DISTANCE ESTIMATION RESULTS

Parameter		Estimation (1)	(2)	(3)	(4)	(5)
Labor supply elasticity	ϕ	0.003	0.167	0.084	0.146	0.149
		(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Lower adjustment cost	f_L	\$0	\$1,377	\$0	\$454	\$378
		—	(\$6)	—	(\$9)	(\$16)
Adjustment-cost probability	λ	1	1	0.124	0.161	0.153
		—	—	(0.002)	(0.002)	(0.004)
Upper adjustment cost	f_H	∞	∞	∞	∞	\$3,191
		—	—	—	—	(\$105)
Time discount factor	β	0.998	0.914	0.934	0.958	0.937
		(0.000)	(0.001)	(0.003)	(0.001)	(0.001)
Scaling parameter	κ	0.179	1.233	0.236	0.697	2.667
		(0.000)	(0.007)	(0.001)	(0.006)	(0.032)
Wage profile parameters	δ_0	10.170	9.360	9.089	9.243	9.667
		(0.002)	(0.004)	(0.004)	(0.004)	(0.003)
	δ_1	0.067	0.074	0.073	0.078	0.064
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	δ_2	−0.001	−0.001	−0.001	−0.001	−0.001
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	δ_0^E	−0.442	−0.440	−0.480	−0.496	−0.473
		(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
	δ_1^E	0.025	0.019	0.022	0.021	0.019
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Persistence of permanent shock	ρ	0.824	0.927	0.922	0.934	0.929
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Std. dev. of permanent shock	σ_ν	0.057	0.223	0.252	0.222	0.224
		(0.000)	(0.000)	(0.001)	(0.001)	(0.001)
Std. dev. of transitory shock	σ_ϵ	0.431	0.133	0.113	0.164	0.150
		(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Std. dev. of individual fixed effects	σ_i	0.575	0.569	0.541	0.591	0.569
		(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Std. dev. of measurement error	ι	0	0	0	0	0.034
		—	—	—	—	(.000)

Notes. This table shows the results from simulated minimum distance (SMD) estimations. Each column corresponds to a separate estimation. Entries in the table are parameter estimates with standard errors in parentheses. Parameters that are fixed and not estimated are indicated with — in place of a standard error. All estimations use the same set of estimation targets described in Online Appendix D.4, except for column (5) which uses the two additional targets described in Section IV.D to identify f_H and ι.

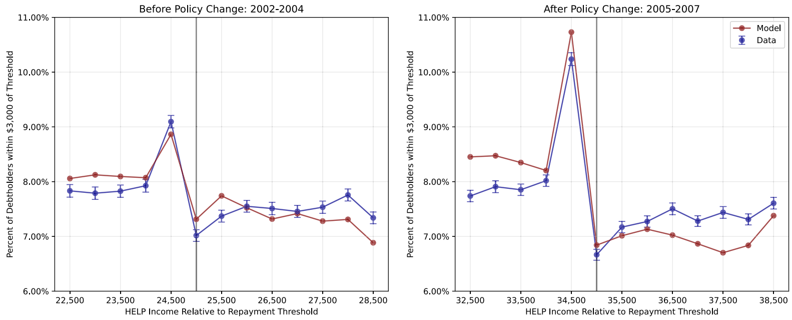

FIGURE VIII

Model Fit: HELP Income Distribution Around the Policy Change

The left panel plots the HELP income distribution within $3,000 of the repayment threshold in bins of $500 for the period before the policy change from 2002 to 2004 in the data, in blue. Bars represent 95% confidence intervals based on bootstrapped standard errors with 1,000 iterations. The red line plots the same quantities from the model with parameters set at the estimated values in Table III, column (1). The right panel replicates the left panel for the period after the policy change between 2005 and 2007. The vertical gray line in each plot indicates the repayment threshold, which is the point at which repayment begins.

primarily identified based on the distribution of changes in labor supply, which is not targeted in the first four columns.

The baseline model provides a close fit to the bunching in the data used to identify the key labor supply parameters, which is shown in Figure VIII. There are some differences in the shape of the distributions because the estimation is balancing the improvement of this fit with matching the age profile of income. Notably, the model replicates the fact that there is more bunching after relative to before the policy change. In the model, this is driven by the increase in the repayment rate at the threshold from 3% before to 4% after the change.

Online Appendix Table IA.V shows that the model can replicate the probability that individuals who bunch below the old repayment threshold in 2004 also bunch below the new repayment threshold, which is how the adjustment probability, λ, is identified. This probability is low (2%) because the increase in the repayment threshold is substantial. Therefore, only a small sample of borrowers who experience sufficiently large wage increases find it optimal to locate below the new (higher) threshold. For the remaining borrowers, increasing their labor supply to locate below the new threshold is too costly in utility terms.

The model's ability to match the heterogeneity in bunching with debt balances is driven by the estimate of the discount factor, $\beta = 0.94$. Finally, through adjusting f_H, the model matches the distribution of observed changes in hours worked, which changes annually for around 60% of individuals. The estimation attributes 80% of these changes to measurement error, with the remaining $60\% \times 0.2 = 12\%$ of individuals actually adjusting their labor supply. This value of 12% is consistent with the estimate of $\lambda = 12.4\%$ for the pure Calvo model in column (3). Twenty-one percent of these adjustments come from individuals with the upper adjustment cost, unlike the model in column (4) with $f_H = \infty$ in which only individuals with the lower cost adjust.

IV.F. Model Validation and Additional Results

Before using the estimated model to perform counterfactual analyses, I show that it provides a reasonable fit to several pieces of evidence that were not targeted in the estimation.

1. *U.K. Evidence in Britton and Gruber (2020) (BG).* BG study taxable-income responses to income-contingent loans in the United Kingdom, where there is a single government-provided income-contingent loan with one repayment rate that determines the marginal repayment rate on income above a repayment threshold. The left panel of Online Appendix Figure IA.XV reproduces Figure 5 from BG, which shows the income distribution for a 10% sample of debtholders between 2006 and 2012 when the threshold was £15,000 and the repayment rate was 9%. BG find that there is evidence of bunching below this threshold, but that the implied elasticity of taxable income (estimated from the static model in Saez 2010) is approximately zero.

The right panel of Online Appendix Figure IA.XV shows that the baseline model replicates this conclusion from BG. To generate this figure, I change the debt repayment parameters in the model to those of the U.K. income-contingent loan. I simulate from the model holding all structural parameters fixed at their estimated values in Table III, column (5). As in BG, the model generates bunching immediately below this threshold, but the elasticity of taxable income (ETI) implied by this bunching is essentially zero.[15] However, this lack of significant bunching does

15. There are two differences between the model and BG. First, the shape of the distributions differs because the wage process was estimated on Australian

not imply that labor supply responses are unimportant. As shown in Section V, the labor supply responses to an income-contingent loan with a marginal repayment rate, like the one in the United Kingdom, that occur away from the threshold account for the majority of the fiscal cost of moving to income-contingent repayment and change optimal contract design. This highlights the value of my empirical evidence relative to BG: because the incentives created by HELP are large enough to generate responses, I can estimate a dynamic model of labor supply that captures the effects of income-contingent repayment both at and further from the threshold, which can be used for policy counterfactuals. In contrast, the evidence from BG alone does not say whether the lack of bunching is driven by a low structural elasticity, the dynamic incentives created by income-contingent repayment, or optimization frictions.

2. *Bunching Heterogeneity.* The left panel of Online Appendix Figure IA.XVI shows a scatterplot of the bunching for different groups based on age and debt balances in the data versus the model. The relationship is positive with an R^2 (correlation) of 52% (72%), indicating that the model does a good job at qualitatively capturing this heterogeneity. However, the model cannot explain the data quantitatively: the estimated intercept and slope coefficients are 1 and 0.4, whereas they would be 0 and 1 if the model fully explained the data.

3. *Bunching Around Tax Thresholds.* The right panel of Online Appendix Figure IA.XVI plots the bunching around the two discontinuities in marginal tax rates closest to the HELP repayment threshold. The bunching around these tax "kinks" is smaller than around the HELP thresholds because these kinks induce a change in marginal rather than average rates. The model replicates this relatively small amount of bunching at these thresholds reasonably well.

4. *Speed of Response to Policy Change.* As shown in Figure I, the bunching in the data around the repayment thresholds re-

data. Second, the model cannot generate the bunching in the income distribution of non-borrowers when the threshold is a round number that BG find. Online Appendix Figure IA.III shows that the same is not true in my sample in 2005, when the threshold was a round number.

sponds rapidly to the change. Online Appendix Figure IA.XVII shows that this immediate response is also present in the model. This may appear surprising given that some people who were bunching in 2004 receive $f_{ia} = f_H$ in 2005, and thus are less likely to adjust ℓ_{ia}. However, the bunching still disappears because $y_{ia} = w_{ia}\ell_{ia}$, which implies that y_{ia} can change even if ℓ_{ia} does not due to fluctuations in w_{ia}.

5. *Within-Individual Variation.* The left panel of Online Appendix Figure IA.XVIII shows that the model matches the probability that individuals who are bunching before the policy change are bunching after the policy change, which was targeted in the estimation, but also the probability that these people remain bunching below the old threshold, which was not targeted. The right panel shows the model matches the average income after the change of individuals who are bunching before it. However, the model misses on the average income before the change of individuals who are bunching after it: in the model, these individuals tend to come from further up in the income distribution than in the data.

6. *Bunching Decomposition.* In Online Appendix D.5, I use the model to decompose the bunching below the repayment threshold into three effects: (i) the wedge between borrowers' discount rate and the debt interest rate; (ii) the fact that borrowers may not pay off their debt; and (iii) a demand for liquidity. I find that the latter two forces are the most important, consistent with the evidence in Section III that the amount of bunching is larger among borrowers with a lower probability of repayment or who appear more liquidity-constrained.

V. Normative Analysis of Income-Contingent Loans

My normative analyses proceed in two steps. First, I study the effects of moving from fixed repayment to different forms of existing income-contingent loans. Because these contracts have different fiscal costs, I assess policies based on their marginal value of public funds (MVPF) (Hendren and Sprung-Keyser 2020). Next, I solve a Ramsey (1927)–style problem to construct income-contingent contracts that maximize borrower welfare while having the same fiscal cost as a fixed-repayment contract. Throughout these analyses, borrowing, education choices, and prices (i.e., wages and interest rates) are held fixed. Therefore, these results are informative about the effects of a mandatory debt restructuring among existing borrowers whose ex ante choices are fixed by definition.[16]

1. *Policy Environment.* The comparison of repayment contracts is contingent on the tax system, $\tau_{ia} = \tau(y_{ia})$, which also provides insurance and redistributes. I adopt the parametric specification from Heathcote, Storesletten, and Violante (2017) calibrated to Australia's tax schedule; see Online Appendix D.3 for additional details. I define the government budget, $\mathcal{G}$, as:

$$\mathcal{G} \equiv \mathbf{E}_0 \left(\sum_{a=a_0}^{a_T} \underbrace{\frac{\tau_{ia} - ui_{ia} - \underline{c}_{ia}}{R^{a-a_0}}}_{\text{taxes and transfers}} + \underbrace{\frac{d_{ia}}{R^{a-a_0}} - D_{ia_0}}_{\text{debt repayments}} \right), \tag{13}$$

where $\mathbf{E}_0(\cdot)$ denotes an expectation taken over all states, including the initial state. I discount at the risk-free rate because there is no aggregate risk in the model. The benchmark contract in my analyses is a fixed-repayment contract without forbearance (i.e., payment pauses for low-income borrowers), where borrowers make constant repayments for 25 years after graduation. I denote the government budget under this contract as $\overline{\mathcal{G}}$. This contract is a natural benchmark because it is available in the United States and has a similar duration to existing income-contingent contracts while being a debt contract. In addition, all contracts that I consider are subsidized with a zero interest rate, like those available in Australia.

2. *Welfare Metrics.* To measure the welfare effects of moving from the benchmark contract to an alternative (income-contingent) contract, p, I use two metrics. The first is the equivalent variation, defined as the transfer that makes a borrower, prior to knowing her initial states, indifferent between repaying under contract p versus repaying under the benchmark contract with the additional transfer at $a = a_0$. The second is the consumption-equivalent gain, defined as the value of g that makes a borrower, prior to knowing her initial states, indifferent

16. To affect my results, these choices would need to respond to the utility value of repayments associated with different degrees, which existing literature suggests are likely small responses (Patnaik, Wiswall, and Zafar 2020).

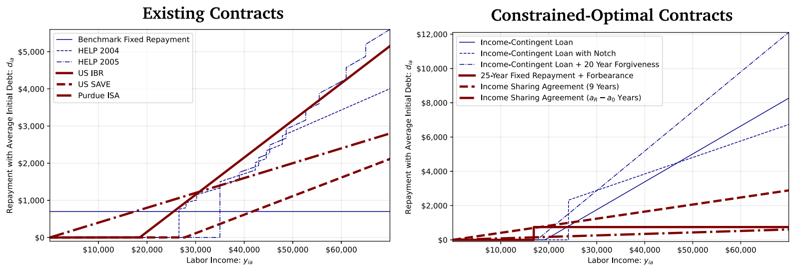

FIGURE IX

Repayment Functions for Existing and Constrained-Optimal Contracts

The left panel of this figure plots the required debt repayments as a function of income for the different existing income-contingent contracts that I consider. The horizontal solid black line corresponds to the benchmark fixed-repayment contract. See Online Appendix D.6 for the exact implementation of each contract. The right panel of this figure plots the constrained-optimal repayment contracts that solve the constrained planner's problem in equation (14) for the different contract spaces described in Section V.B.

between repaying under contract p versus repaying under the benchmark contract and having her consumption increased by $g\%$ in every state (Bénabou 2002). I denote these two metrics by π_p and g_p, respectively. I compute these metrics solely among college-educated borrowers with $\mathcal{E}_i = 1$; see Online Appendix D.7 for additional details.

V.A. *Effects of Existing Income-Contingent Contracts*

I begin by studying the welfare and fiscal effects of moving from the benchmark fixed-repayment contract to various existing income-contingent contracts with repayment formulas shown in the left panel of Figure IX. The first two are the 2004 and 2005 HELP contracts. The next two are the income-based repayment (IBR) formula currently used in the United States and the newly proposed IBR formula known as SAVE, both of which set repayments equal to a fixed fraction of income above a threshold. Relative to the HELP contracts, these latter two contracts induce a change in marginal rather than average repayment rates. The final formula is an income-sharing agreement or equity contract offered by Purdue University, in which borrowers repay a share of their income for nine years (Mumford 2022).

The first three rows of Table IV show that there are significant welfare gains to moving from the benchmark fixed-

TABLE IV

EFFECTS OF MOVING FROM 25-YEAR FIXED REPAYMENT TO ALTERNATIVE CONTRACTS

Policy: p	π_p	Δ Repayments	Δ Taxes & transfers	$\Delta\mathcal{G}_p$	MVPF	g_p (%)
HELP 2004	\$4,879	\$217	−\$1,200	−\$983	4.96	1.39
HELP 2005	\$6,004	−\$185	−\$1,450	−\$1,635	3.67	1.68
U.S. IBR	\$3,989	\$647	−\$1,163	−\$516	7.73	1.14
U.S. SAVE	\$7,578	−\$2,033	−\$1,078	−\$3,111	2.44	2.08
U.S. IBR + fixed cap	\$5,518	−\$1,006	−\$447	−\$1,453	3.80	1.55
U.S. SAVE + fixed cap	\$8,171	−\$3,018	−\$683	−\$3,702	2.21	2.23
U.S. IBR + forgiveness	\$4,265	−\$573	−\$1,171	−\$1,745	2.44	1.22
U.S. SAVE + forgiveness	\$7,926	−\$4,445	−\$925	−\$5,370	1.48	2.17
Purdue ISA	\$1,984	\$1,069	−\$1,808	−\$738	2.69	0.59
Debt cancellation	\$10,912	−\$14,026	\$391	−\$13,634	0.80	2.89

Notes. This table shows the effects of moving from the benchmark 25-year fixed-repayment contract to alternative repayment contracts from the left panel of Figure IX indicated in the first column. The second column shows the equivalent variation, π_p. The third and fourth columns show the change in the government budget that comes from changes in debt repayments and taxes and transfers individually; the fifth column sums these two columns to generate the total fiscal impact. The sixth column computes the marginal value of public funds (MVPF) computed by dividing the second and (negative one times) fifth columns. The final column shows the consumption-equivalent welfare gain, g_p. See Online Appendix D.6 for the exact implementation of each contract. The rows with "+ fixed cap" correspond to contracts where individuals cannot repay more than they would under the benchmark fixed-repayment contract. The rows with "+ forgiveness" correspond to contracts where all debt is forgiven after 20 years. The final row, "Debt cancellation", corresponds to borrowers not repaying any of their debt. The model used for these analyses is the model estimated in Table III, column (5).

repayment contract to HELP and U.S. IBR. These welfare gains are equivalent to cash transfers of \$4,000–\$6,000, or 23%–35% of the average initial debt, and a 1.1%–1.7% increase in lifetime consumption. Given the differences in fiscal cost, a better way to compare these contracts is to compute their MVPFs, defined as $-\frac{\pi_p}{\Delta\mathcal{G}_p}$. Table IV shows that these MVPFs range from 3.7 to 7.7, with U.S. IBR having the highest value. As a benchmark, the median MVPF for expenditure policies in the Policy Impacts Library is 1.5 and the 75th percentile is 6.7 (as of December 2024). Therefore, the MVPFs from income-contingent loans are sizable, especially since the highest values typically come from policies that target children rather than adults (Hendren and Sprung-Keyser 2020).

The fourth row of Table IV shows that the new SAVE loan introduced by the Biden administration generates almost twice the welfare gains of the first three contracts but is about three times as costly. This is because the SAVE repayment formula, shown in the left panel of Figure IX, has a very low repayment rate. Because the fiscal cost of this contract is so high, its MVPF is around 70% lower than that of the current U.S. IBR program. This suggests that the SAVE's more generous repayment formula is not a well-targeted subsidy.

Most income-contingent loans in the United States, unlike in Australia, have a cap that prevents borrowers from repaying more than under the benchmark fixed-repayment contract. I find that adding this cap lowers the MVPF of U.S. IBR by over 50% to 3.8, which suggests that a desirable aspect of income-contingent loans is the faster repayment from higher-income borrowers. For U.S. SAVE, adding this cap only decreases the MVPF by about 10% because the lower repayment rate makes the cap binding for fewer borrowers. In addition, I find that adding forgiveness after 20 years, another common feature of loans in the United States, is undesirable in terms of an MVPF: for U.S. IBR, the MVPF declines by around 70% to 2.4. This is because forgiveness is a poorly targeted subsidy once income-contingent repayment has been implemented: lower-income borrowers who value it most already repay less, so the subsidy primarily benefits higher-income borrowers who value it less.

The final two policies that I consider are the income-sharing agreement offered by Purdue University and full debt cancellation, in which all debt is forgiven. Table IV shows that the income-sharing agreement has a lower MVPF than most of the income-contingent loans. This is because a pure income-sharing agreement requires repayments from all borrowers, while existing income-contingent loans allow zero payments from borrowers with sufficiently low incomes. The final row of Table IV shows that debt cancellation increases borrower welfare by more than any of the other contracts considered, but it is sufficiently costly that it has an MVPF below one. This is because full debt forgiveness is a very inefficient policy: income-contingent loans can provide around 40% of the welfare gain of moving from fixed repayment to full forgiveness at around only 4% of the fiscal cost.

1. *Decomposition of Fiscal Cost.* Online Appendix Table IA.VI decomposes the fiscal cost of moving from the benchmark to alternative contracts into two components: (i) the change in fiscal cost assuming labor supply remains fixed; and (ii) the change in fiscal cost that comes from adjustments in labor supply. For the two HELP contracts and U.S. IBR, which have the highest

MVPFs, as well as the income-sharing agreement, more than 100% of fiscal cost is driven by adjustments in labor supply. This highlights the importance of having a quantitative model of labor supply to correctly estimate the effects of income-contingent repayment.

V.B. Constrained-Optimal Income-Contingent Contracts

This section studies optimal policy by solving a Ramsey (1927)–style constrained planner's problem. This analysis has two goals. First, it quantifies the welfare gains of transitioning from fixed to income-contingent repayment without relying on other policy instruments to balance the government budget. Second, it provides insight into the shape and features of constrained-optimal income-contingent loans.

1. *Constrained Planner's Problem.* The planner is constrained to choose one mandatory contract p from the following contract spaces that have two parameters, ψ_p and K_p:

(i) Income-contingent loan: $d_{ia}(\psi_p, K_p) = \min\left\{\psi_p \times \max\left\{y_{ia} - K_p, 0\right\}, D_{ia}\right\} \times \mathbf{1}_{a \leqslant a_R}$
(ii) Income-contingent loan with notch: $d_{ia}(\psi_p, K_p) = \min\left\{\psi_p \times y_{ia} \times \mathbf{1}_{y_{ia} \geqslant K_p}, D_{ia}\right\} \times \mathbf{1}_{a \leqslant a_R}$
(iii) Income-sharing agreement (T years): $d_{ia}(\psi_p, K_p) = \psi_p \times y_{ia} \times \mathbf{1}_{a-a_0 \leqslant T}$

Aside from tractability, the restriction of the contract space is motivated by practical constraints that make implementing more complicated policies difficult (Piketty and Saez 2013). The first contract space is the class of income-contingent loans in the United States and United Kingdom, where individuals repay a fixed fraction of their marginal income, ψ_p, above a threshold, K_p. The second is the same as the first, except that the income threshold at K_p changes the average rather than marginal rate, like HELP. The third is income-sharing agreements, where individuals pay a ψ_p share of their income for T years regardless of debt levels.

Given a contract space, the constrained planner's problem that determines ψ_p and K_p is:

$$\max_{\psi_p \in [0,1],\, K_p \geqslant 0} \mathbf{E}_0 \left(V_{ia_0} \mid \mathcal{E}_i = 1 \right),$$

subject to:

$$\mathbf{E}_0 \left(\sum_{a=a_0}^{a_T} \frac{\tau_{ia} - ui_{ia} - \underline{c}_{ia} + d_{ia}(\psi_p, K_p)}{R^{a-a_0}} - D_{ia_0} \right) \geqslant \overline{\mathcal{G}}. \tag{14}$$

The planner's objective function is the expected indirect utility of a hypothetical borrower who is "behind the veil of ignorance" with respect to her initial states and views the realization of these states as risk. This objective implicitly depends on the two policy parameters through the debt repayment function. The constraint that the planner faces is that the government budget under the chosen policy parameters be at least as large as under the benchmark contract. Solving expression (14) is numerically challenging; I leverage a combination of barrier methods and a global optimizer detailed in Online Appendix D.8.

2. *Constrained-Optimal Income-Contingent Loan.* The first row of Table V shows the results from solving for the constrained-optimal income-contingent loan, and the right panel of Figure IX plots repayments as a function of income at the optimal parameters. The optimal ψ_p and K_p are around 16% and \$19,000, implying that this contract collects zero repayments from borrowers in the bottom 11th percentile in the income distribution. Relative to the existing contracts, this contract has a repayment threshold that is lower than HELP and U.S. SAVE but close to that of U.S. IBR.[17] Unlike U.S. IBR, this contract has a higher repayment rate of 16% relative to 10% to balance the government budget. The welfare gain from this contract is equivalent to a cash transfer of \$2,800 or 0.8% increase in lifetime consumption, which is sizable: it corresponds to 16% of average initial debt and over a quarter of the gain from forgiving debt balances entirely. It is lower than the contracts in Table IV, but because this income-contingent loan is budget-balanced, it has an MVPF of infinity.

17. In U.S. IBR, K is 1.5 times the U.S. federal poverty line, which was US\$14,580 for a single household in 2023. Deflating to 2005 US\$ and converting to AU\$ implies a value of $K =$ AU\$18,480.

TABLE V

PARAMETERS AND WELFARE EFFECTS OF CONSTRAINED-OPTIMAL CONTRACTS

Contract space: p	ψ_p (%)	K_p	π_p	g_p (%)	$\psi_p^{\ell \text{ fixed}}$ (%)	$K_p^{\ell \text{ fixed}}$
Income-contingent loan	16	\$19,188	\$2,778	0.79	38	\$39,702
Income-contingent loan with notch	9.6	\$24,093	\$1,508	0.46	15	\$47,001
Income-contingent loan + 20 year forgiveness	23	\$17,533	\$1,128	0.36	32	\$29,516
25-year fixed repayment + forbearance	0.54	—	\$267	0.10	0.12	—
Income sharing agreement (9 years)	4.1	—	\$1,730	0.52	3.6	—
Income sharing agreement ($a_R - a_0$ years)	0.87	—	\$6,549	1.82	0.78	—

Notes. This table shows the effects of moving from the benchmark 25-year fixed-repayment contract to constrained-optimal repayment contracts that solve expression (14) within the different contract spaces indicated in the first column. The optimal contract parameters are shown in the second and third columns and plotted in the right panel of Figure IX. For 25-year fixed repayment + forbearance, which is described in Section V.B, ψ_p corresponds to the (net) debt interest rate, r_d. The fourth and fifth columns show the two welfare metrics, π_p and g_p. The final two columns show the optimal contract parameters from solving expression (14) assuming that ℓ_{ia} remains fixed at its value under the benchmark contract for all i and a. The objective function in the latter column does not include the disutility of labor supply, given that labor supply is held fixed. The model used for these analyses is the model estimated in Table III, column (5).

The positive welfare gain from the constrained-optimal income-contingent loan implies that its insurance benefits outweigh the costs of the moral hazard and distortions in consumption-saving decisions it creates. Nevertheless, labor supply responses still have a significant effect on contract design. The final two columns of Table V show the results from solving expression (14), assuming that labor supply is fixed at its value under the benchmark contract. The optimal ψ_p and K_p are over twice as large, which provides substantially more insurance to borrowers and increases welfare by an additional 0.9 percentage points of lifetime consumption (Online Appendix Figure IA.XIX). Because this contract cannot raise sufficient revenue with endogenous labor supply, the constrained-optimal contract lowers the repayment threshold to collect repayments from more borrowers and the rate to induce smaller responses.

3. *Constrained-Optimal Income-Contingent Loan + Notch.* The second row of Table V shows the results for the constrained-optimal income-contingent loan with a notch, like in Australia, rather than a kink, like in the United States and United Kingdom. This contract has a lower repayment rate and higher thresh-

old than the first income-contingent loan. Although a notch causes a larger behavioral response, it also collects more revenue from individuals at the threshold who do not adjust due to optimization frictions. As a result, the planner collects substantially more revenue from these borrowers, allowing for higher K_p. However, even with the higher threshold, this contract has a welfare gain that is about 40% lower than in the first income-contingent loan. This suggests that formulating an income-contingent loan with a notch is suboptimal, but it is still preferable to using fixed repayment. In contrast, Online Appendix Table IA.VII shows that in the model estimated in Table III, column (4) with $f_H = \infty$, having a notch does not decrease welfare. As the repayment threshold and hence the size of the notch increases, there are always borrowers who will not respond if $f_H = \infty$. In contrast, with $f_H < \infty$, the notch can only be so large before all borrowers start responding.

4. *Anticipated Forgiveness.* The third row of Table V shows the results from solving expression (14) using the same contract space in the first row, but adding forgiveness at $a_0 + 20$, as in U.S. IBR. Adding forgiveness reduces the welfare gain from the constrained-optimal income-contingent loan by over 50% because the repayment rate must be increased and the threshold decreased to balance the government budget. Given that older borrowers are those who receive the forgiveness, this effectively results in a transfer of repayments from older to younger borrowers, which reduces welfare because younger borrowers have a higher marginal value of wealth from tighter borrowing constraints and stronger precautionary motives (Gourinchas and Parker 2002; Boutros, Clara, and Gomes 2022).[18]

5. *Fixed-Repayment Contracts with Forbearance.* In the United States, fixed-repayment contracts allow repayments to be delayed for low-income borrowers who enter deferment, forbearance, or default. As of 2019, 30% of debt was in one of these three

18. If individuals are present-biased, then forgiveness may be a useful way to target middle-aged people with inadequate retirement savings that are still paying off their debt. However, if this is the goal that forgiveness aims to achieve, other policy tools may be more desirable, such as reforming the retirement pension system, which could benefit all present-biased individuals independently of whether they have debt.

states (US DoE). While modeling strategic default is beyond the scope of this article (see Ji 2021), I evaluate its importance by adding forbearance to the benchmark fixed-repayment contract that is available for borrowers receiving unemployment insurance and adjusting the debt interest rate to balance the government budget.[19] The fourth row of Table V shows that fixed repayment with forbearance increases welfare by the equivalent of 0.1% of lifetime consumption, only 13% of the gain from income-contingent loans. These smaller gains echo the results in Section V.A and reflect the benefits of the call option–like structure of an income-contingent loan, which collects repayments more quickly from high-income borrowers. Although these borrowers are likely to pay off their debt, the acceleration of these repayments in time increases their present value, allowing the planner to provide more insurance.

6. *Income-Sharing Agreements*. Income-sharing agreements (ISAs) were originally proposed by Friedman (1955) and motivated the development of income-contingent loans. Although private provision has been limited by adverse selection (Herbst and Hendren 2021), my model can be used to examine their effectiveness as a mandated government-provided contract. The fifth row of Table V shows the results for an ISA with a nine-year duration, which is the duration of the ISAs offered by Purdue University (Mumford 2022). Relative to fixed repayment, the nine-year ISA improves welfare by the equivalent of 0.52% of lifetime consumption, which is 35% lower than the constrained-optimal income-contingent loan. This underperformance primarily comes from concentrating repayments early in borrowers' lives when they are more liquidity-constrained. The final row of Table V shows that an ISA with a repayment horizon of borrowers' entire working life has a welfare gain that outperforms the income-contingent loan. However, for reasons described in Online Appendix D.9, these gains primarily reflect redistribution across initial states, especially based on debt balances because repayments do not depend on the amount borrowed. This suggests that this ISA is more likely to generate ex ante responses outside of the model, such as additional borrow-

19. This contract likely overstates the benefits of forbearance because it is freely accessed an unlimited number of times, while in the United States it can only be used a fixed number of times and has negative consequences.

ing and selection, that would undermine their effectiveness and make income-contingent loans a more robust implementation of income-contingent repayment.[20]

V.C. Additional Results and Robustness

1. *Insurance–Redistribution Decomposition.* The planner's objective in expression (14) implies that redistribution across initial conditions and ex post realizations of shocks are both viewed as insurance. In Online Appendix D.9, I decompose welfare gains into the components that come from these two channels separately. For the constrained-optimal income-contingent loan, I find that both channels contribute half of the gains. In contrast, ISAs create significantly more redistribution because they decouple repayments from debt balances.

2. *Interaction with the Tax System.* Online Appendix D.10 compares the distribution of welfare gains from the constrained-optimal income-contingent loan to the distribution in an alternative policy experiment in which debt repayment remains unchanged but the tax system is optimized. The three main differences are that (i) changing the tax system affects individuals of all education levels, (ii) higher-income individuals lose substantially from the change in the tax system because they have to make larger repayments throughout their lives, and (iii) restructuring debt repayment more effectively targets people with high debt balances.

3. *Sensitivity to Key Parameters.* In Online Appendix D.11, I vary the four key parameters that govern labor supply responses (ϕ, λ, f_L, f_H) and resolve expression (14) for this range of possible values. For the income-contingent loan to deliver a welfare loss relative to the benchmark fixed-repayment contract, I estimate ϕ would need to be above 0.24, which is well outside the confidence interval for its estimated value. When $\phi = 0.24$, Online Appendix D.12 explores how using a richer con-

20. Another reason these gains are likely an upper bound is because ϕ is identified from median-income borrowers. However, the borrowers making the bulk of the repayments under ISAs have higher incomes; prior literature suggests that these borrowers have higher taxable-income elasticities (e.g., Gruber and Saez 2002).

tract space can restore welfare gains from income-contingent repayment.

4. *Model Misspecification.* Online Appendix D.13 discusses how the solution to expression (14) varies across many alternative models with alternative risk and time preferences, tax systems, income processes, initial debt levels, government discount rates, and wealth effects on labor supply.

VI. Conclusion

This article studies the trade-off between insurance and moral hazard in student loans with income-contingent repayment. Empirically, I show that borrowers reduce their labor supply to lower income-contingent repayments and that these responses are consistent with a moderate elasticity of labor supply and substantial optimization frictions. Through the lens of a structural model, these estimates imply that income-contingent repayment provides significant welfare gains and that income-contingent loans are an effective and robust way of doing so. Relative to fixed-repayment contracts with forbearance, income-contingent loans provide more insurance by accelerating payments from high-income borrowers. Relative to equity contracts, the welfare gains involve less redistribution, making them less likely to generate ex ante responses (e.g., additional borrowing) and to be adversely selected.

The results speak to the “student debt crisis” in the United States (Mitchell 2019) by providing empirical evidence and a structural model that can be used to calibrate the effects of student debt restructuring. Overall, the results suggest that a (mandatory) restructuring of the $1.6 trillion of U.S. student debt from fixed to income-contingent repayment would be beneficial. However, this analysis leaves open several questions, most important, how education, occupation, and borrowing choices respond (Hampole 2022; Murto 2022; Abourezk-Pinkstone 2023). Quantifying these responses and their implications for contract design is an important task for future research. More broadly, this study suggests there is scope to incorporate state contingencies into other financing contracts, such as shared-appreciation mortgages (Benetton et al. 2022) or revenue-based loans (Russel, Shi, and Clarke 2023).

Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online.

Data Availability

The data underlying this article are available in the Harvard Dataverse, https://doi.org/10.7910/DVN/D2G7CC (de Silva 2025).

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