College Loans and Human Capital Investment*

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Abstract

College loans serve as a double-edged sword for human capital investment: While they facilitate access to education, the burden of repayment may distort post-education investments in human capital. We examine the role of college loans and loan repayment policies through a structural model in which heterogeneous individuals, faced with borrowing limits, make dynamic decisions on consumption, borrowing/saving, labor supply, and costly human capital investment (via both college education and on-the-job learning à la Ben-Porath (1967)). We estimate two versions of the model using data from the NLSY79: one with natural borrowing limits and another with parameterized limits. Counterfactual simulations based on both models suggest that, relative to the standard fixed repayment plan, income-driven repayment (IDR) plans modestly increase educational attainment, lifetime earnings, and individual welfare. Although some generous IDR plans may result in losses for the loan program itself, overall government revenue is higher under IDRs than under the standard repayment plan when lifetime income taxes are accounted for, creating a win-win scenario for both individual welfare and government revenue.

Keywords: Human Capital Investment, Borrowing Limits, College Loans, Welfare, Government Revenue

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1 Introduction

By facilitating educational investment, particularly for individuals from resource-constrained families, college loans play an important role in equalizing opportunities and improving welfare *ex ante*. However, the burden of loan repayment constitutes a financial constraint that may distort workers' post-education human capital investment, thereby generating *ex-post* inefficiency.[1] In addition, workers with college debt may begin their careers at a disadvantage relative to otherwise identical peers without such debt, resulting in *ex-post* inequality. In this paper, we analyze the "double-edged sword" nature of college loans and quantify how repayment policies shape this trade-off.

We build and estimate a dynamic model of individuals' post-high school decisions on consumption, borrowing/saving, labor supply, and human capital investment in the form of college education and on-the-job investment. The model incorporates three features that are essential for our research questions. First, human capital investment is costly. College education entails both monetary and opportunity costs, while on-the-job investment reduces current earnings in exchange for higher future earnings, as in Ben-Porath (1967). Second, individuals are subject to two types of financial constraints. The first is borrowing constraints, which can distort decisions regarding college education and on-the-job investment. The second is the burden of college loan repayment borne by those who borrowed for college education. Given the importance of borrowing constraints, which are typically unobservable to researchers, we take particular care and employ two distinct specifications that are well established in the literature. In one specification, we follow Keane and Wolpin (2001) and estimate a parameterized borrowing limit (PBL) function from the data. In the other, we build on Hai and Heckman (2017) and derive the natural borrowing limit (NBL) (Aiyagari, 1994), accounting for one's labor supply and human capital investment choices. Finally, because our objective is to evaluate loan repayment policies, it is essential to recognize that individuals' choices are partly driven by factors unobservable to the researcher. Our model explicitly incorporates unobserved heterogeneity across individuals in their preferences, initial human capital, effectiveness in accumulating human capital, and, through their impact on human capital, borrowing limits.

We apply our model to data from the National Longitudinal Survey of Youth (NLSY79), which provides detailed information on individuals' educational choices and their career paths for periods both before and after repayment of their college loans under the standard plan. We estimate both versions of our model, with different specifications of borrowing constraints, using the method of indirect inference.

Using our estimated models, we conduct two sets of counterfactual policy simulations. *A posteriori*, both PBL and NBL versions of the model yield similar policy implications. In the first set of counterfactual simulations, college loans are unexpectedly forgiven upon workers' entry into the labor market. This simulation serves two purposes. First, it quantifies how the burden of loan repayment can distort, *ex post*, an individual's career path. Second, it helps to understand the effect of similar

[1] The burden of college debts can distort one's career choices beyond its effect on human capital investment, as we discuss in the literature review section.

policies that may be implemented in exceptional situations (e.g., COVID-era debt relief). Compared to their baseline decisions, workers whose debt is forgiven invest more in human capital, resulting in lower early-career earnings (approximately \$1,617 less in the first year under PBL) in exchange for higher lifetime earnings and wealth. By age 45, these workers, on average, hold \$440 more in human capital and \$1,150 more in assets than in the baseline.

In the second set of counterfactual experiments, we examine how alternative repayment policies affect individuals' educational and career trajectories by contrasting two IDR cases with the baseline: one resembling the Saving on a Valuable Education plan (SAVE), introduced in 2023 under the Biden administration, and the other resembling the Repayment Assistance Plan (RAP) announced by the Trump administration in May 2025 and scheduled to take effect for new borrowers beginning July 1, 2026. In each case, all individuals are fully informed of the repayment policy when making educational and borrowing decisions; upon leaving college, a borrower chooses between a fixed repayment plan and a given IDR plan. Relative to the baseline (the standard repayment plan), both SAVE and RAP modestly increase college enrollment, degree completion, and lifetime earnings. SAVE yields larger gains in individual welfare than RAP (\$9,500 vs. \$7,360, on average). Although SAVE generates a lending loss of \$515 per person, higher tax revenue results in a net fiscal gain of \$1,805 per person. RAP leads to a smaller gain of \$1,109 in government revenue. Overall, the results suggest that IDR policies can generate a win-win outcome by enhancing both individual welfare and government revenue.

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 provides a first look at the data, which motivates the model presented in Section 4. Section 5 describes the data in detail. Section 6 describes our estimation method, followed by estimation results in Section 7. Section 8 conducts counterfactual policy experiments. Section 9 concludes the paper. Additional details and tables are in the appendices.

2 Related Literature

There has been an extensive body of work on the effect of credit constraints on individuals' educational choices (e.g., Carroll, 1997, Cameron and Heckman, 1998, Keane and Wolpin, 2001, Carneiro and Heckman, 2002, Carroll et al., 2003, Cameron and Taber, 2004, Belley and Lochner, 2007, Stinebrickner et al., 2008, Johnson, 2013, and Lochner and Monge-Naranjo, 2016). Our paper builds on this literature and examines the effect of credit constraints on one's educational and post-education choices, and how credit constraints interact with the burden of college loan repayment in shaping these choices.

The literature has used different approaches to modeling credit constraints. Some studies (e.g., Keane and Wolpin, 2001 and Johnson, 2013) treat borrowing limits as a function of age and human capital with free parameters to be estimated from the data. Other studies model borrowing constraints in a more disciplined way.[2] For example, Lochner and Monge-Naranjo (2011) study the interaction between borrowing constraints and investment in human capital during schooling years, where bor-

[2]See Hai and Heckman (2017) for a comprehensive review of the literature on this issue.

rowing constraints are derived from government student loan programs and private lending under limited commitment. Hai and Heckman (2017) estimate a dynamic model of schooling, labor supply, work experience, and saving with uninsured human capital risks and borrowing constraints. They model credit constraints as model-determined limits derived from an analysis of private lending with a natural limit (Aiyagari, 1994) combined with access to government student loan programs; theirs is the first analysis that incorporates the natural borrowing limit in such a rich framework. They use their model to investigate the role of cognitive ability, noncognitive ability, and family background in explaining inequality in education, earnings, and consumption. They find substantial evidence of life-cycle credit constraints that affect human capital accumulation and inequality. Moreover, borrowing limits vary with age and are lower for individuals with lower human capital and higher psychic costs of working. Comparing their model with one where borrowing limits are fixed at sample means stratified by education level (Abbott et al., 2019), they find that the latter overpredicts the effect of tuition policies.[3] We model borrowing constraints in two specifications, building on Keane and Wolpin (2001) and Hai and Heckman (2017), respectively.

The recent rise in college debt has drawn growing attention to how debt burdens affect individuals' choices. For example, studies have found that the burden of college loans can negatively affect the take-up of public-interest jobs (Field, 2009; Rothstein and Rouse, 2011), entrepreneurship (Morazzoni, 2022), household formation (Goodman et al., 2021), and homeownership (Mezza et al., 2020), and it can also distort college major choices (Hampole, 2024). Through the lens of quantitative lifecycle models of consumption and saving, recent studies have looked at how student debt affects one's post-education choices and welfare (Ji, 2021; Folch and Mazzone, 2022; Boutros et al., 2024; de Silva, 2024). Incorporating college loans' effects on both educational and career choices in a lifecycle model, Luo and Mongey (2019) highlight the amenity-wage trade-off induced by student debt. Through a survey, Fu et al. (2025) study how loan repayment policies affect individuals' human capital investment and career choices.

Our paper also builds on the broad literature on the relationship between human capital investment and life-cycle wage growth, which follows the Ben-Porath (1967) model. Earlier work that explicitly estimates the Ben-Porath model includes Heckman (1975, 1976), Haley (1976), Rosen (1976), and Heckman et al. (1998a,b). For example, Heckman (1976) extends Ben-Porath (1967) and presents more general human capital models in which each individual makes decisions on labor supply, investment, and consumption. More recently, Fan et al. (2024) focus on the later part of one's career and estimate a Ben-Porath model with endogenous retirement.

Our paper is closely related to studies that use the Ben-Porath framework to analyze the effects of college loans on skill investment. Ionescu (2009, 2011) calibrates lifecycle models of college enrollment, loan take-up and repayment, on-the-job investment, and earnings, while Alon et al. (2024) adds occupational choices to a similar framework. Our paper, which focuses on individuals' choices, differs

[3] With a similar model-determined borrowing limit, Hai and Heckman (2019) estimate a dynamic model of schooling, health behavior, and wealth in order to quantify causal relationships between education and health.

in several important aspects. First, we place a particular emphasis on modeling borrowing limits, an important yet unobserved component of individual decision-making. Unlike prior studies, which either prohibit borrowing (Ionescu, 2009), assume no limits except in default (Ionescu, 2011), or impose a common exogenous borrowing cap (Alon et al., 2024), we adopt two alternative specifications well-received in the literature. Our specifications are more flexible, allowing borrowing limits to depend on an individual's (evolving) earnings potential. Second, we incorporate rich observable and unobservable heterogeneity across individuals and estimate all major structural parameters jointly within the model, utilizing micro-level panel data. Third, we study how the design of IDR plans affects individuals' choices and welfare, contributing to ongoing student loan reform debates.

3 A Glance at the Data

As we describe in detail in Section 5, our data consist of a sample of white males from NLSY79. To motivate some of our modeling choices, we provide a first glance at our data and show profiles of wage growth for two groups of college-educated workers: college loan borrowers and non-borrowers. Specifically, among college-educated workers, we calculate each individual's annual wage growth on full-time jobs over time and report the average among individuals in each subgroup by educational attainment and loan status. The left panel of Figure 1 shows that among those with some college education (but without a Bachelor's degree), college loan borrowers have lower wage growth throughout the first ten years of their career, compared to non-borrowers. The right panel shows that relative to those without college loans, college graduates with loans have lower wage growth in the first few years of their career but higher wage growth later on.

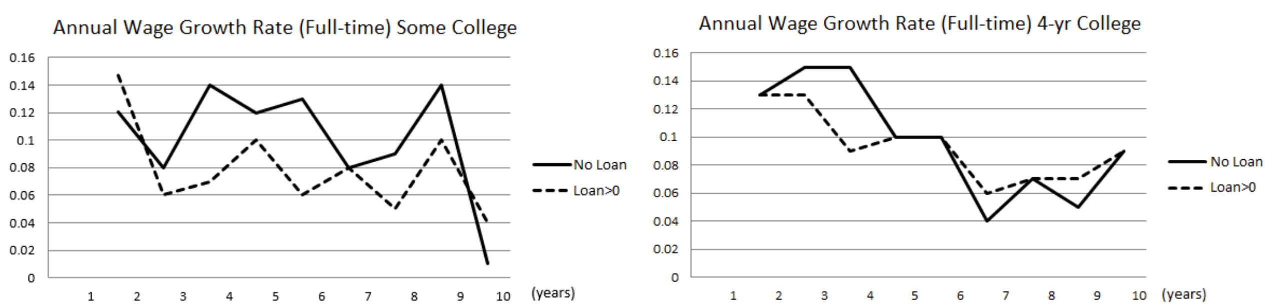

Figure 1: Wage Growth for Workers with and without Loans by Education

While not excluding other explanations, patterns shown in Figure 1 are consistent with the hypothesis that the burden of repaying college loan debt may put workers at a disadvantage and lead them to underinvestment in their human capital at the beginning of their career. These patterns motivate us to model wage growth as an endogenous result from costly human capital investment as in Ben-Porath (1967). However, cross-group comparison may lead to biased views as it is confounded by unobserved differences between borrowers and non-borrowers. To obtain a solid understanding of patterns such as those in Figure 1 and to conduct counterfactual policy simulations, we resort to the structural model we describe next.

4 Model

We model an individual's post-high school dynamic decisions on labor supply, human capital (HK) investment (via college education and/or on the job), and borrowing/saving (including loan take-up), subject to a borrowing constraint. An individual makes decisions in each of the T periods, which can be divided into (at most) three endogenous stages: pre-college, college, and post-education, with the duration of each stage being governed by one's college enrollment choice (no college, 2-year college, or 4-year college), college retention choices, and college graduation probabilities.

4.1 Primitives

4.1.1 Initial Endowment

Upon high school graduation ($t = 0$), an individual is endowed with characteristics X (AFQT score, parental education and income), a type $\chi \in \{1, 2\}$, and an initial HK level k_0. Both χ and k_0, unobservable to the researcher, are correlated with X, such that

$$\Pr(\chi = 2|X) = \frac{\exp(X'\theta)}{1 + \exp(X'\theta)} \text{ and } k_0 = K_0(X, \chi). \tag{1}$$

That is, the distribution of χ types varies by X and the initial HK level k_0 differs by both X and χ.

4.1.2 Human Capital Production and Earnings

There are two HK investment channels. The first is college education, where one can make enrollment choice $s_t \in \{0, 2, 4\}$ (not enrolled, two-year college, four-year college). The second channel is on-the-job HK investment, where a worker allocates a fraction $i_t \in [0, 1]$ of his HK for skill investment and rents the rest to the labor market. One cannot engage in college education and on-the-job HK investment at the same time.

College The return to college education is uncertain. Letting t^e be the period one chooses to enter college—where $s_{t^e} \in \{2, 4\}$ denotes the chosen type of college—the probability π_t that an *enrollee* completes college at the end of period t is given by:

$$\pi_t = \begin{cases} 0 \text{ if } t < t^e + s_{t^e} - 1, \\ \Pi(X, \chi, s_{t^e}) \text{ if } t \geq t^e + s_{t^e} - 1. \end{cases} \tag{2}$$

That is, a two-year (four-year) college enrollee faces a positive graduation probability $\Pi(\cdot)$ starting from his second (fourth) college year. Letting t^o be one's first post-college period and $g \in \{0, 2, 4\}$ be one's degree (high school, associate, bachelor), upon leaving college, one's HK increases from k_{t^e} (HK upon enrollment) to k_{t^o}, such that

$$k_{t^o} = k_{t^e} + I\left(g = 0\right)\kappa_0\left(s_{t^e}\right) + I\left(g = s_{t^e}\right)\kappa_1\left(s_{t^e}\right). \tag{3}$$

In other words, after his education in an s-year college, one's HK is enhanced by $\kappa_0\left(s\right)$ if he fails to graduate and by $\kappa_1\left(s\right)$ if he graduates, for $s \in \{2, 4\}$.[4]

Following Hai and Heckman (2017, 2019), we assume that while in college, one can work at most part-time and earn

$$y_t = w_c h_t, \tag{4}$$

where $h_t \in \{0, 1\}$ (non-employment, part-time) is one's in-college labor supply choice and w_c is the wage rate faced by college students.[5]

On-the-Job For a type-χ worker with work status $h_t \in \{0, 1, 2\}$ (non-employment, part-time, full-time) and a degree $g \in \{0, 2, 4\}$, who uses a fraction $i_t \in [0, 1]$ of his current HK (k_t) for investment, his HK at the beginning of $t + 1$ is given by

$$k_{t+1} = K^J\left(k_t, i_t, h_t, g, \chi\right). \tag{5}$$

On-the-job HK investment involves an opportunity cost in the form of foregone earnings (Ben-Porath, 1967); one's period-t earnings are given by

$$y_t = p_{h_t} k_t (1 - i_t) e^{\eta_t}, \tag{6}$$

where $p_0 = 0$ and hence $y_t = 0$ if one does not work; p_1 and p_2 are rental rates of HK on part-time and full-time jobs respectively; η_t is an i.i.d. wage shock.

4.1.3 Budget Constraints

To highlight the role of college loan repayment policies, we divide one's total assets a_t into one's non-college loan assets $\left(a_t^n\right)$ and college loans $\left(l_t\right)$, i.e., $a_t = a_t^n - l_t$. Upon high school graduation, we assume $a_0 = a_0^n = l_0 = 0$. To ease exposition, we define $\widetilde{a}_t^n$ as a_t^n plus interests and define $\widetilde{l}_t^n$ similarly:

$$\widetilde{a}_t^n \equiv a_t^n\left(\left(1 + r^l\right) I(a_t^n > 0) + (1 + r^b) I(a_t^n < 0)\right),\ \widetilde{l}_t \equiv l_t\left(1 + r^c\right),$$

[4] Equation (3) implies that *conditional* on the same attainment, college education's effects (κ's) on one's human capital are common across individuals. However, individuals have different probabilities of succeeding in college and hence different expected returns from enrollment.

[5] The assumption of a common wage rate for college students is consistent with the data: Conditional on working, the correlation of in-college earnings with AFQT (a proxy for ability) is close to zero (-0.016), in contrast, out of college, this correlation is 0.355.

where r^l, r^b and r^c are the interest rates for lending, non-college loan, and college loan, respectively.[6]

Non-College Periods Letting l_{t^o} be one's college loan accumulated upon leaving college, one's consumption in a non-college period t is given by

$$c_t = \max\left\{y_t - \tau(y_t) + \widetilde{a}_t^n - LP\left(l_{t^o}, t\right) - a_{t+1}^n, \underline{c}\right\}. \tag{7}$$

One's resources include one's after-tax earnings $y_t - \tau(y_t)$ and non-college loan assets plus interests $\widetilde{a}_t^n$. This resource is used to fund period-t college loan repayment $LP\left(l_{t^o}, t\right)$, next-period's non-college loan assets a_{t+1}^n, and current consumption c_t. With public transfers, consumption c_t is bounded from below by the consumption floor $\underline{c}$.[7]

In the baseline, we specify $LP\left(l_{t^o}, t\right)$ such that one pays back his college loans according to the standard plan as described in Smole (2013). This plan was used by more than 90% of college loan borrowers in the cohorts covered by our data (Scherschel, 1998). Under the standard plan, one pays back their college loan l_{t^o} within the first 10 years starting from t^o, with the annual payment given by

$$LP\left(l_{t^o}, t\right) = \begin{cases} l_{t^o} \frac{(1+r^c)^9}{\sum_{t=1}^{10}(1+r^c)^{t-1}} \text{ if } t^o \leq t \leq 9 + t^o, \\ 0 \text{ otherwise.} \end{cases} \tag{8}$$

Given this payment plan, the post-college evolution of one's college loan debt is given by

$$l_{t+1} = \left(l_t - LP\left(l_{t^o}, t\right)\right) \times (1 + r^c) \text{ for } t \geq t^o. \tag{9}$$

College Periods Letting $NC\left(s, X\right)$ be the tuition net of college grant for a student X enrolled in college type s. The resources available for one to fund one's consumption and net tuition payment consist of one's after-tax earnings $y_t - \tau(y_t)$, parental transfer $Tr\left(X, t, NC\left(s, X\right)\right)$ (a function of X, age, and net tuition), and borrowing. One's consumption in college periods is given by

$$c_t = \max\left\{y_t - \tau(y_t) + Tr\left(X, t, NC\left(s, X\right)\right) - NC\left(s, X\right) + \widetilde{a}_t^n - a_{t+1}^n + \Delta l_t, \underline{c}\right\}, \tag{10}$$

where $\widetilde{a}_t^n - a_{t+1}^n$ is the change in one's non-college loan assets and Δl_t is the amount of college loan taken in period t, such that $l_{t+1} = \widetilde{l}_t + \Delta l_t$.

Borrowing Limits Because borrowing limits are a very important yet unobserved factor underlying individuals' choices, we take extra caution in our modeling choice and use two different specifications

[6] A more rigorous notation should make r^c period-policy-dependent because under all but one policy we consider, r^c is zero during college; our empirical analysis respects these policy features.

[7] When an individual is at both the consumption floor $\underline{c}$ and the borrowing limit $\underline{b}_{t+1}$, there may be multiple levels of i_t supporting this scenario. In that case, we assume the lowest i_t among the ones that support $\left(\underline{c}, \underline{b}_{t+1}\right)$ to avoid individuals heavily engaging in investment while free-riding on $\underline{c}$, which is presumably implausible. However, we have also re-estimated the model without this assumption; our estimates and counterfactuals are robust.

that are well-received in the literature. In the first specification, we follow Keane and Wolpin (2001) and model one's borrowing limits as a parametric function of age and HK, but we allow the limit to differ in college years versus non-college years. In addition, as in Lochner and Monge-Naranjo (2011) and Johnson (2013), a college student's borrowing limit is increased by the government college loan $L^{gov}(\cdot)$. That is, under the parameterized borrowing limits (PBL), one faces the following constraint

$$a_{t+1}^{n} - l_{t+1} \geq \underline{b}_{t+1} = \begin{cases} -\exp\left(\phi_0 + \phi_1 t + \phi_2 k_t\right) \text{ if } t < t^e \text{ (pre college)} \\ -\exp\left(\phi_0 + \phi_1 t + \phi_2 k_t + \phi_3\right) - L^{gov}\left(t - t^e\right) \text{ if } t^e \leq t < t^o \text{ (in college)} \\ \min\left\{-\exp\left(\phi_0 + \phi_1 t + \phi_2 k_t\right),\ \widetilde{a}_t^n - l_{t+1}\right\} \text{ if } t \geq t^o \text{ (post college),} \end{cases} \tag{PBL}$$

where ϕ_3 allows one's borrowing limit to differ in college versus out of college, for reasons beyond $L^{gov}(\cdot)$.

In the second specification, we follow Hai and Heckman (2017) and assume that before college, one faces an endogenous natural borrowing limit (NBL); during college, one can borrow up to the greater of the NBL and the limit allowed under the government college loan program $L^{gov}(\cdot)$; after college, the borrowing limit can be in one of the following two situations. First, if an individual's borrowing does not exceed his NBL limit, the borrowing limit will be set to the amount of the natural borrowing limit. Second, if an individual borrows more than the NBL limit, this can only happen if the agent borrows more during college, where this individual borrows from student loan programs. In this case, we set the borrowing limit equal to the current debt level. This setting is similar to Hai and Heckman (2017), capturing the fact that these individuals do not need to pay back the loan immediately. Letting $|B_t(\cdot)|$ be the maximum amount an individual can repay with certainty, one's borrowing constraint is given by

$$a_{t+1}^{n} - l_{t+1} \geq \underline{b}_{t+1} = \begin{cases} B_t(l_{t^o}, k_{t+1}, \chi) \text{ if } t < t^e \text{ (pre college)} \\ \min\left\{B_t(l_{t^o}, k_{t+1}, \chi),\ -L^{gov}\left(t - t^e\right)\right\} \text{ if } t^e \leq t < t^o \text{ (in college)} \\ \min\left\{B_t(l_{t^o}, k_{t+1}, \chi),\ \widetilde{a}_t^n - l_{t+1}\right\} \text{ if } t \geq t^o \text{ (post college)} \end{cases} \tag{NBL}$$

As detailed in Appendix A.2, our derivation of the natural borrowing limit $B_t(\cdot)$ extends Hai and Heckman (2017) to account for one's HK investment decision $i_t \in [0,1]$ in addition to one's labor supply decision $h_t \in \{0,1,2\}$.

Notice that both specifications account for the role of government college loan programs. More importantly, they both relate individuals' borrowing limits to their endogenous earnings potential. This relationship arises by definition under NBL and by the inclusion of HK in the borrowing limit under PBL.[8] That being said, there are two caveats. First, NBL is derived under full enforcement of repayment; we abstract from how limited commitment may affect one's ability to borrow. Second, in PBL, we assume that parameters governing borrowing constraints are invariant to our counterfactual policies.

[8]Hai and Heckman (2017) points out that for policy evaluations, it is important to account for the fact that workers' borrowing limits may vary with their human capital levels.

4.1.4 Timing

Time is discrete with $t = 1, ..., T$. These periods can be divided into up to three endogenous stages—Stage A (pre-college periods), Stage B (college periods), and Stage C (post-education periods)—by t^e (college entry time) and t^o (first post-college period), both endogenously chosen.[9]

To save on computation, we set $T = 28$ (at age 45) and make three assumptions: 1) while allowing for late completion, we assume that once leaving college, one cannot return, and 2) the latest age for *initial* college enrollment is $T^s = 10$. These assumptions imply that enrollment choice $s_t = 0$ if $t \geq \min\{t^o, T^s + 1\}$. Now, we describe the timing of events within each stage and how one transits from one stage to the next.

Stage A ($t \leq \min\{t^e, T^s\}$) At the beginning of each period t, one observes his contemporaneous preference shocks for college choices ζ_t and chooses $s_t \in \{0, 2, 4\}$ (no college, two-year college, four-year college).[10]

- A1: If $s_t = 0$, one observes shocks to his labor supply preferences and wages (ϵ_t and η_t) and makes decisions with respect to period-t labor supply, on-the-job HK investment, and borrowing/saving. In $t + 1$, if $t < T^s$, one stays within Stage A; if $t = T^s$, one moves to Stage C when the labor market is an absorbing state.

- A2: If $s_t > 0$, one enters college, observes their choice-specific preference shocks ε_t and makes decisions about in-college labor supply and borrowing/saving. In $t + 1$, one enters Stage B.

Stage B ($t^e < t < t^o$) At the beginning of each t, an enrollee observes his preference shocks ζ_t and chooses $s_t \in \{0, s_{t^e}\}$ (dropout, stay in college).

- B1: If $s_t = 0$, one enters Stage C.

- B2: If $s_t > 0$, one observes their choice-specific preference shocks ε_t and makes decisions about in-college labor supply and borrowing/saving. With probability π_t (given by (2)), one completes college and enters Stage C in $t + 1$; with probability $(1 - \pi_t)$, one stays in Stage B in period $t + 1$.

Stage C ($t \geq \min\{t^o, T^s + 1\}$) At the beginning of each t, one observes shocks to his labor supply preferences and wages (ϵ_t and η_t) and makes decisions with respect to period-t labor supply, on-the-job HK investment, and borrowing/saving.

[9]To ease exhibition, we set $t^e = T + 1$ for one without any college experience yet and $t^o = T + 1$ if one has not left college.

[10]We view s as one's highest attempt; in the data, if an individual has attended both two-year and four-year colleges, we categorize him as having chosen a four-year college upon initial (two-year or four-year) enrollment.

4.2 Individuals' Problem

We solve an individual's problem by backward induction, starting from Stage C to Stage A. In defining value functions, we use superscripts A, B, C to denote the stage and Ω_t^{Stage} to denote the state variable in period t at a given stage (detailed in Appendix A.3). We solve the model by simulation and employ discretization of continuous choice variables and value function interpolation (Online Appendix C).

4.2.1 Stage C (Post-Education)

For each $t \geq \min\{t^o, T^s + 1\}$, an individual chooses his non-college loan assets for the next period a_{t+1}^n, work status h_t, and HK investment i_t to solve the following problem

$$V_t^C\left(\Omega_t^C\right) = \max_{a_{t+1}^n, h_t \in \{0,1,2\}, i_t \in [0,1]} \left\{u\left(c_t, h_t, \chi\right) + \epsilon_t\left(h_t\right) + \beta E V_{t+1}^C\left(\Omega_{t+1}^C\right)\right\} \tag{11}$$

$$\begin{aligned} s.t.\ c_t &= \max\left\{y_t - \tau(y_t) + \widetilde{a}_t^n - LP\left(l_{t^o}, t\right) - a_{t+1}^n, \underline{c}\right\} \\ k_{t+1} &= K^J\left(k_t, i_t, h_t, g, \chi\right), \\ y_t &= p_{h_t} k_t (1 - i_t) e^{\eta_t}, \\ a_{t+1}^n - l_{t+1} &\geq \underline{b}_{t+1}, \end{aligned}$$

where $u(\cdot)$ is the utility from consumption c_t and work status h_t, $\epsilon_t(h_t)$ is choice-specific shocks to one's labor supply, and β is the discount factor. An individual faces four constraints: the budget constraint, the HK production function, the earnings function, and the borrowing constraint, given by PBL (NBL) in the first (second) model specification. Notice that since wages are subject to shocks, a heavier burden of loan repayment and/or a tighter borrowing limit would strengthen individuals' incentives to save against bad wage shocks. The model closes at $t = T$, with the terminal value given by a type-dependent function of one's assets a_T and HK k_T :

$$V_T^C\left(\Omega_T^C\right) = V^*\left(a_T, k_T; \chi\right).$$

4.2.2 Stage B (College)

For each $t^e < t < t^o$, an enrollee observes his preference shock ζ_t and decides whether or not to drop out:[11]

$$V_t^B\left(\Omega_t^B\right) = \max_{s_t \in \{0, s_{t^e}\}} \left\{ \begin{array}{l} \sigma_\zeta \zeta_t(0) + E V_t^C\left(\Omega_t^C : k_t = k_{t^e} + \kappa_0\left(s_{t^e}\right)\right) \text{ if } s_t = 0 \\ \sigma_\zeta \zeta_t\left(s_{t^e}\right) + E\widetilde{V}_t^B\left(\Omega_t^B\right) \text{ if } s_t = s_{t^e} \end{array} \right\}, \tag{12}$$

where $\zeta_t(s_t)$ is an i.i.d. choice-specific preference shock. If one drops out, he obtains the expected value as a worker $V^C(\cdot)$ given by (11). In this case, one's post-college HK is enhanced to $k_{t^e} + \kappa_0(s_{t^e})$ as specified in (3). If one stays in college, he obtains the expected value of $\widetilde{V}_t^B(\cdot)$ given by

[11] We assume that if an enrollee fails to complete a two-year college within $s_{t^e} + 4$ years, he drops out for sure at the end of $t^e + s_{t^e} + 4$. Similarly, if an enrollee fails to complete a four-year college within $s_{t^e} + 9$ years, he drops out for sure at the end of $t^e + s_{t^e} + 9$.

$$\widetilde{V}_t^B\left(\Omega_t^B, s_{t^e}\right) = \max_{d_t, a_{t+1}^n}\left\{\begin{array}{l} u\left(c_t, h_t, \chi\right) - \lambda_e(h_t) + \psi\left(X, \chi, t, s_{t^e}\right) + \sigma_\varepsilon \varepsilon_t\left(d_t\right) + \left(1-\pi_t\right)\beta E V_{t+1}^B\left(\Omega_{t+1}^B\right) \\ +\pi_t \beta E_{\epsilon_{t+1}, \eta_{t+1}} V_{t+1}^C\left(\Omega_{t+1}^C : k_{t+1} = k_{t^e} + \kappa_1\left(s_{t^e}\right)\right) \end{array}\right\} \tag{13}$$

$$\begin{aligned} s.t.\ & c = w_c h_t - \tau(w_c h_t) + Tr\left(X, t, NC\left(s, X\right)\right) - NC\left(s, X\right) + \widetilde{a}_t^n - a_{t+1}^n + \Delta l_t \\ & \pi_t \text{ defined in } (2), \\ & a_{t+1}^n \left\{\begin{array}{l} = \widetilde{a}_t^n \text{ if } \Delta l_t > 0 \text{ and } \widetilde{a}_t^n < 0 \\ \leq \widetilde{a}_t^n \text{ if } \Delta l_t > 0 \text{ and } \widetilde{a}_t^n > 0 \end{array}\right. \\ & l_{t+1} = \widetilde{l}_t + \Delta l_t, \\ & a_{t+1}^n - l_{t+1} \geq \underline{b}_{t+1}. \end{aligned}$$

In (13), $d_t \equiv (\Delta l_t, h_t)$ is the discrete choices of loan take-up Δl_t and in-college labor supply h_t; while $u(.)$ captures one's preferences for consumption and leisure that are common across all periods, $\lambda_e(h_t)$ allows for additional disutility from work while studying at the same time; $\psi(\cdot)$ captures the non-pecuniary benefits/costs of college life that varies with X, type, age, and college type; $\varepsilon_t(d_t)$ are choice-specific preference shocks.[12] With probability $(1-\pi_t)$ one stays in Stage B in $t+1$ and obtains the expected value of $V_{t+1}^B(\cdot)$, the $t+1$ counterpart of (12). With probability π_t, one completes college and enters the labor market in $t+1$ with HK $k_{t^e} + \kappa_1(s_{t^e})$. For asset choice a_{t+1}^n, we impose a non-arbitrage constraint to prevent one from borrowing the low-interest college loan to repay his high-interest pre-college debt.

4.2.3 Stage A (Pre-College)

For each $t \leq \min\{t^e, T^s\}$, one makes a college enrollment choice $s_t \in \{0, 2, 4\}$ to solve the following problem

$$V_t^A\left(\Omega_t^A\right) = \max_{s_t \in \{0,2,4\}}\left\{\begin{array}{l} \sigma_\zeta \zeta_t\left(s_t\right) + E\widetilde{V}_t^B\left(\Omega_t^B, s_t\right) \text{ if } s_t \in \{2,4\} \\ \sigma_\zeta \zeta_t\left(0\right) + E\widetilde{V}_t^A\left(\Omega_t^A, 0\right) \text{ if } s_t = 0 \end{array}\right\}, \tag{14}$$

where $\zeta_t(s_t)$ is an i.i.d. choice-specific preference shock. If one chooses to enroll in college $s_t \in \{2, 4\}$, one obtains the expected value of an enrollee $\widetilde{V}_t^B(\Omega_t, s_t)$ (defined in (13)); if one chooses not to enroll

[12] These preference shocks help to rationalize some data patterns that are otherwise hard to explain, e.g., a student borrows college loans while having savings $a_t^n > 0$.

in college, one obtains the expected value $E\widetilde{V}_t^A\left(\Omega_t^A, 0\right)$ with $\widetilde{V}_t^A\left(\Omega_t^A, 0\right)$ given by

$$\widetilde{V}_t^A\left(\Omega_t^A, 0\right) = \max_{a_{t+1}^n, h_t \in \{0,1,2\}, i_t \in [0,1]} \left\{ \begin{array}{c} u\left(c_t, h_t, \chi\right) + \epsilon_t\left(h_t\right) + I\left(t \geq T^s\right) \beta E_{\epsilon_{t+1}, \eta_{t+1}} V_{t+1}^C\left(\Omega_{t+1}^C\right) \\ +I\left(t < T^s\right) \beta E_{\zeta_{t+1}} V_{t+1}^A\left(\Omega_{t+1}^A\right) \end{array} \right\} \tag{15}$$

$$\begin{aligned} s.t.\ c_t &= \max\left\{y_t - \tau(y_t) + \widetilde{a}_t^n - a_{t+1}^n, \underline{c}\right\} \\ k_{t+1} &= K^J\left(k_t, i_t, h_t, g, \chi\right), \\ y_t &= p_{h_t} k_t (1 - i_t) e^{\eta_t}, \\ a_{t+1}^n &\geq \underline{b}_{t+1}. \end{aligned}$$

If $t \geq T^s$ (the last year for college enrollment), $\widetilde{V}_t^A\left(\Omega_t, 0\right)$ is the same as the Stage-C value specified in Equation (11); if $t < T^s$, one can still enroll in college in $t+1$ and stay in Stage A with value $V_{t+1}^A(\cdot)$.

5 Data

The National Longitudinal Survey of Youth 1979 (NLSY79) provides information about individuals' characteristics and family backgrounds, educational and loan take-up choices, as well as the trajectories of work status, wages, and assets. Our analysis focuses on the 3,180 white males with at least a high school degree from the main sample.[13] From this group, we exclude 692 individuals who attended graduate school, 439 individuals missing key information (AFQT, parental education, parental income, or age entering college), 136 individuals who graduated from high school after the age of 20, and 119 individuals who completed their college education after age 35. The final sample includes 1,794 individuals, whom we follow until the age of 45 (terminal age in our model). The number of individual-year wage observations is 22,718, and that of individual-year asset observations is 16,744, after excluding outliers.[14] Throughout the paper, all dollar values are in 2012 USD. In the following, we provide empirical definitions of variables that are not self-explanatory.

Education College enrollment choice is defined as the highest education level one has ever attempted. In particular, one who attended both two-year and four-year colleges is defined as choosing a four-year college. To define degree (in)completion, we use data on the highest degree obtained, the year and month of its completion, and the highest grade attended. Enrollment durations are winsorized at 4 years for two-year colleges and 9 years for four-year colleges.

Assets and College Loans For $t \geq 1$, net assets $(a_t - l_t)$ are calculated as the sum of the following six items (i) housing, (ii) savings and checking accounts, money market funds, retirement accounts,

[13] We focus on this group to avoid complications arising from life events that are more relevant for certain groups (e.g., childbearing for women) and to reduce computational burdens during the estimation were we to include more heterogeneous groups (e.g., demographic-group-specific parameters).

[14] Outlier individual-year observations are those with asset levels beyond the top/bottom 3 percent or wages out of the top/bottom 1 percent.

stocks, bonds, (iii) farm operation, business or professional practice, other real estate, (iv) vehicles (v) other items worth individually more than \$500, and (vi) other debts over \$500. Each individual reported the amount of college loans taken for every college attended; l_{t^o} refers to the total sum. However, the asset survey did not explicitly ask about the amount of unpaid college loans over time. As shown in Keane and Wolpin (2001), unpaid college loans are included in item (vi).

Period-T Natural Borrowing Limit In the specification of NBL, the natural borrowing limit in the last period, $B_T(\cdot)$, is set at the fifth percentile of the asset distribution among individuals aged 44 to 46 in our sample ($-\$1,215$).

Work Status While not in college, an individual is said to work full-time in year t if the average number of weekly hours is 30 or more and the number of weeks worked is 40 or more in t. Among the others, one is said to work part-time in year t if his average weekly hours in t are between 10 and 30, and is considered to be non-employed in year t if his average weekly hours in t are below 10. While in college, one is said to work in year t if their average number of weekly hours is 10 or more.

Wages We measure wages using the hourly rate of pay variable in NLSY79. If one worked on more than one job during a week, we use the hourly wage of the main job. As in Johnson (2013), we use the cross-week average of this hourly wage measure as one's hourly wage in a given year. This measure is used as an outcome variable in our auxiliary models.

Remark 1 *NLSY79 and NLSY97 are two natural data sets for the empirical application of our model. We choose NLSY79 as our data source mainly for two reasons. First, a main focus of our paper is on the interaction between college loan repayment and post-education human capital investment; NLSY79, being a longer panel than NLSY97, allows us to follow an individual for more years, and in particular, before and after they paid back their college loans. Second, neither NLSY79 nor NLSY97 contains information on one's repayment plan choices. For NLSY79 cohorts, it is relatively reasonable to assume that individuals follow the standard 10-year plan because options were limited and the standard plan was chosen by over 90% of borrowers in those years (Scherschel, 1998). In contrast, later cohorts were given more repayment options, and borrowers' choices became more diversified based on aggregate statistics. As such, it is critical to observe individual repayment plan choices in order to properly study the NLSY97 cohorts. That being said, the cost of college education has been growing over time, making college loans and repayment policies even more important for more recent cohorts. In Online Appendix F, we use our estimated model to simulate the impact of higher tuition on individuals' educational and career paths, as well as the importance of repayment policies at higher tuition levels.*

5.1 Summary Statistics

Table 1 summarizes educational and loan choices overall (Column 1) by AFQT (Column 2) and by parental education (Columns 3-4). The first four rows report the fractions of college enrollees and degree holders. College enrollment and attainment increase with AFQT and parental education. For example, among individuals with above-median AFQT scores, over 63.8% attend four-year colleges and 42.5% hold a Bachelor's degree, while the corresponding figures in the overall sample are 41.5% and 24.4%. Similarly, those with higher parental education are much more likely to enroll in (60.4%) and complete (42.4%) a four-year college education. The last row shows that an average enrollee borrowed $4,830 for college. This average is higher than the amount borrowed by college enrollees with higher AFQT ($5,750), who predominantly choose four-year over two-year colleges; similarly, loan amount increases, on average, with enrollees' parental education.

Table 1: Educational Choices and Average College Loan Amounts

	All	AFQT>Median	Parental Educ.	
			<HS	>HS
2-year College Enrollees (%)	17.5	16.5	16.2	17.2
4-year College Enrollees (%)	41.5	63.8	21.3	60.4
2-year College Graduates (%)	9.9	13.0	6.4	12.1
4-year College Graduates (%)	24.4	42.5	8.0	42.4
College Loans|Enrollment ($1,000)	4.7 (8.3)	5.5 (8.8)	3.9 (7.2)	4.9 (8.4)

Notes: Cross-individual standard deviations are reported in parentheses. All dollar values are measured in 2012 USD.

Table 2 summarizes outcomes in early career (first 5 years post-schooling) and later career (Age 40-44) by educational attainment and college loan take-up. The first four rows show work status. Since the majority of individuals work full-time, the next two rows report hourly wages on full-time jobs. Work hours and hourly wages both increase with educational attainment (especially in early periods) and experience. Although the differences are not statistically significant, it is interesting to compare borrowers with their no-loan counterparts. Compared to those without college loans, in the some-college group, borrowers are less likely to work full-time early on and earn lower hourly wages in both their early and later career stages. This pattern is different among those with four-year degrees: Compared to those without college loans, borrowers are more likely to work full time early on, earn higher wages in the first 5 years ($23.1 vs. $21.4) but slightly lower wages in their 40s ($43.2 vs. $44.2). The last row summarizes net assets at age 45: Borrowers have lower assets than their non-borrower counterparts.

6 Estimation

As detailed in Appendix B, we preset a subset of model parameters (the risk aversion coefficient, the discount factor, the consumption floor, and the in-college wage rate) and policy parameters (interest rates, the tax schedule, college tuition and grants, and the government college loan schedule). Structurally, we use the indirect inference method to estimate model parameters that govern 1) preferences, 2) the distribution of types and initial human capital levels, 3) the parental transfer function, 4) college

Table 2: Post-Education Outcomes

	High School	Some College		Four-Year College Graduates	
		No Loan	Loan > 0	No Loan	Loan > 0
% Full-time (First 5 years)	68.1	83.5	79.9	84.0	87.1
% Part-time (First 5 years)	22.7	11.1	15.1	11.6	10.5
% Full-time (Age 40-44)	87.8	88.8	90.1	93.7	93.0
% Part-time (Age 40-44)	5.7	6.0	4.7	3.7	5.1
Full-time Wage ($) (First 5 years)	15.0 (6.2)	20.4 (9.4)	19.0 (10.2)	21.4 (10.1)	23.1 (9.3)
Full-time Wage ($) (Age 40-44)	22.7 (10.5)	30.0 (17.7)	27.9 (20.2)	44.2 (28.5)	43.2 (22.6)
Net Assets age 45 ($1,000)	65.8 (123.1)	81.5 (150.1)	72.7 (120.9)	162.5 (279.1)	112.5 (176.0)
Total Obs.	740	445	175	173	261

Notes: Standard deviations are reported in parentheses. All dollar values are measured in 2012 USD.

graduation probabilities, 5) human capital production functions (in college and on the job), 6) human capital rental prices and the wage distribution, 7) the terminal value function, and 8) the borrowing limit function (applicable only to the PBL version of the model).

Identification Our model extends the classical Ben-Porath framework to include two financial constraints: the borrowing constraint and the burden of college loan repayment. Similar to other dynamic models with unobserved types, the identification relies on the panel data structure, combined with exclusion restrictions and functional form assumptions. In the following, we provide the intuition for our model identification, which guides the design of our auxiliary models. Although all parameters are jointly identified, it is more intuitive to present our identification argument for some key model components in parts.

The first important parameter is the human capital depreciation rate (δ). The classical argument used to identify this parameter in the Ben-Porath model is that workers will stop investing in their human capital near the end of their working years, the wage profile of these workers identifies the depreciation rate of human capital (e.g., Heckman et al., 1998a). We focus on one's earlier career and hence cannot use the same argument. However, due to the burden of loan repayment, individuals with large college debts are effectively unable to invest in their human capital.[15] The depreciation rate of human capital, which is assumed to be common among all agents, is thus identified using a similar non-investment argument, although the non-investment in our case arises from the loan repayment burden rather than age. Given δ and the normalization that the HK rental rate on full-time jobs $p_2 = 1$, on-the-job HK production parameters are mainly identified from workers' wage profiles over time, as in Heckman et al. (1998b).

Turning to the human capital production in college, the key parameters are the effects of college attainment on HK, i.e., κ's in Equation (3). For the identification of these parameters, a direct source of

[15] These individuals can still invest in their human capital if they borrow a significant amount of new debt to repay their college loans. However, new debt (change in assets) is observed by us, and therefore, we can infer who is most likely unable to invest in their human capital.

information is the within-individual post- versus pre-college wage difference among those who worked before college. We can learn about κ's from this selected sample thanks to the assumption that *conditional* on the same attainment, the effect of college education on one's human capital is common across individuals.

To identify parameters governing the probability of completion function $\Pi(X, \chi, s)$, we have made an important assumption that once reaching year $s = 2, 4$ in college of type s, the hazard rate $\Pi(\cdot)$ is assumed constant from that point onward. This greatly facilitates the identification since state dependence is, in general, hard to separate from permanent heterogeneity (Heckman, 1981). Given this assumption, $\Pi(\cdot)$ is largely identified by the number of years one spent to complete college.

To gauge the effect of college loans on one's career path, we need to separate the true effect of the burden of college loans from the (endogenous) correlation between college loans and one's unobserved type. To that end, we exploit the known formula of the college loan repayment. Specifically, although one's type is permanent, the burden of loan repayment lasts only for the first 10 years of one's career under the standard repayment plan. Therefore, within-individual comparison across different periods of one's career (e.g., first ten years versus the later years) gives us information about the effect of the burden of loan repayment. In contrast, the comparison across two otherwise equivalent individuals who have different loan amounts combines both the effect of the burden of loan repayment and the difference in their types. Combining the between- and within-individual comparisons informs us of the correlation between college loans and unobserved types.

Finally, because one's type χ is time invariant, its distribution relies heavily on the panel structure of the data, which records the same individual's dynamic decisions over time. For example, an individual who borrows to attend college, graduates on time, and has high lifetime earnings is likely to be the type who has higher efficiency in producing HK.

Auxiliary Models Based on the identification argument above, we design our auxiliary models as follows. We target the following 141 auxiliary model parameters to estimate 64 (60) structural parameters for the model with PBL (NBL). Throughout our auxiliary models, an individual is said to have large (small) loans if their total college loan is above (below) the average loan level among loan borrowers within the same college education group (some college or four-year college graduates). It should be noted that auxiliary regressions only serve as a succinct way to summarize the data; their coefficients should not be interpreted as causal effects.

1. First moments of wages and assets by potential experience among high school graduates, some-college educated with small/large loans, four-year degree holders with small/large loans.[16]

2. The average difference between one's pre-college wage and post-college wage for each of the following four groups (among those who work before college): two-year college non-completers and completers, and four-year college non-completers and completers.[17]

[16] We group every two years of potential experience in calculating these moments.

[17] We use two-year averages for both the pre- and the post-college wages.

3. Coefficients from the OLS regression of the post-college (log) hourly wage of the following form:

$$\ln(wage_t) = X\alpha^w + d_{edu} + \beta_1^w l_{t^o} + t\left(\beta_2^w + \beta_3^w I(t < 10 + t^o)\right) + \beta_4^w t^2 \\ + t\left(\beta_5^w + \beta_6^w I(t < 10 + t^o)\right) I(large\ loan) + \beta_7^w expfull_t + \beta_8^w I(h_t = fulltime), \quad (16)$$

where α^w captures the correlation between wages and characteristics X; d_{edu} is an education-attainment dummy; β_1^w relates wages to college loans, β_2^w to β_4^w capture wage profiles over potential years of post-college experience (t), allowing for a break before and after the 10^{th} year (when college loans are paid off under the standard plan); β_5^w and β_6^w capture how wage growth (overall and in the first 10 years) differs for those with large college loans. In addition, we use the correlations between wages and full-time job experience ($expfull_t$) and full-time work status to inform us of how skill production and skill prices differ between full-time and part-time jobs.

4. Post-schooling work status by education attainment and large/small loan.

5. College-related moments

   i) Enrollment: Two-year and four-year college enrollment rates overall and by AFQT group; average number of years between high school graduation and college enrollment.

   ii) Completion and Duration: Completion rates among two-year and four-year enrollees overall and by AFQT group; on-time college completion rates among two-year and four-year enrollees; average years spent enrolled in college by two-year and by four-year enrollees.

   iii) Average total college loans among two-year and four-year enrollees overall and by AFQT group; variance of total college loans among college enrollees.

   iv) The fraction of college enrollees who work during a college year, overall and by AFQT.

7 Parameter Estimates and Model Fit

In this section, we report the estimation results for the PBL version of the model; in Online Appendix E, we report the results for the NBL version of the model.

7.1 Parameter Estimates

We report model estimates of the main parameters of interest in Table 3 and the rest in Table A2; standard errors (in parentheses) are calculated via bootstrapping.

Panel A of Table 3 shows estimates of parameters governing the human capital (HK) production function. Our estimated HK capital annual depreciation rate is around 1.5%, and the elasticity of HK production with respect to investment is around 0.96, and that with respect to HK stock is around 0.83. We find that Type 2 individuals are more efficient in producing HK than Type 1 individuals $(A_2 > A_1)$. We also find that workers are penalized for working part-time. First, HK production when

Table 3: Selected Parameter Estimates

A. HK production: $k_{t+1} = (1-\delta)k_t + \alpha_{0h} A_\chi i_t^{\alpha_1} k_t^{\alpha_2}$		
Skill depreciation rate (δ)	0.015	(0.001)
Elasticity w.r.t. investment (α_1)	0.961	(0.031)
Elasticity w.r.t. human capital stock (α_2)	0.828	(0.004)
Type 1 factor (A_1)	0.090	(0.002)
Type 2 factor (A_2)	0.143	(0.003)
Part-time factor (α_{01})	0.716	(0.018)
B. Skill price for part-time jobs (p_1)	0.378	(0.011)
C. Disutility from Work		
Part-time work (Type 1) (λ_{11})	0.788	(0.008)
Part-time work (Type 2) (λ_{12})	0.082	(0.003)
Full-time work (Type 1) (λ_{21})	0.978	(0.013)
Full-time work (Type 2) (λ_{22})	0.473	(0.016)
Work during college λ_e	1.082	(0.026)
D. College Preference		
Constant term (ψ_0)	-32.045	(0.312)
AFQT score (ψ_1)	6.792	(0.141)
Type 2 (ψ_2)	15.143	(0.279)
Age (ψ_3)	-2.344	(0.018)
4-year college (ψ_4)	5.070	(0.097)
4-year college for Type 2 (ψ_5)	1.095	(0.078)
E. Graduation Probabilities: $\Pi = \exp(\mathbf{X}'\rho) / (1 + \exp(\mathbf{X}'\rho))$		
Constant term (ρ_0)	-1.256	(0.013)
AFQT score (ρ_1)	2.430	(0.159)
Type 2 (ρ_2)	0.647	(0.085)
4-year college (ρ_3)	-0.815	(0.018)
4-year college for Type 2 (ρ_4)	0.520	(0.014)
F. Human Capital Gain from College Education: $\kappa(s_t^e)$		
Dropping Out from 2-year ($\kappa_0(s_t^e = 2)$)	1.232	(0.065)
2-year Degree ($\kappa_1(s_t^e = 2)$)	3.765	(0.036)
Dropping Out from 4-year ($\kappa_0(s_t^e = 4)$)	1.898	(0.050)
4-year Degree ($\kappa_1(s_t^e = 4)$)	4.347	(0.033)
G. Parental Transfer: $Tr = \exp(\mathbf{X}'\iota)$		
Constant term (ι_0)	1.356	(0.028)
Net Tuition (ι_1)	0.576	(0.021)
Age (ι_2)	-0.105	(0.002)
Parents' income (33-66 percentile) (ι_3)	0.201	(0.012)
Parents' income (67-100 percentile) (ι_4)	0.424	(0.019)
4-year college (ι_5)	0.127	(0.003)

working part-time is only around 72% as effective as in the case of working full-time (α_{02} is normalized to 1), presumably due to fewer training opportunities for part-time jobs. Second, as Panel B shows, given the same HK rented out to the market, an individual working part-time earns less than half (38%) of the annual salary compared to working full-time.

Panel C shows that Type 2 individuals have lower disutility from work. Panel D shows that individuals with higher AFQT scores and Type-2 individuals enjoy college more, that college preferences decline as one ages, and that four-year colleges are more enjoyable, especially for Type 2 individuals. Panel E shows that higher-AFQT and Type 2 individuals face higher college graduation probabilities. On average, a four-year education is riskier (with a lower graduation rate) but less so for Type 2 individuals. Panel F shows estimates of the human capital gain from college education. Although a partial college education increases one's human capital, the magnitude is small (1.23 for some 2-year and 1.90 for some 4-year education); completing a college education increases one's human capital 2-3 times as much (3.76 for 2-year and 4.35 for 4-year completion). Finally, Panel G shows that parental (annual) transfers for college students increase with net tuition and family income, decrease with students' age, and are slightly larger for four-year college enrollees.

As shown above, our estimates suggest that Type 2 individuals have advantages over their Type 1 counterparts: Type 2's have higher efficiency in on-the-job HK production, higher college graduation rates, lower distutilities from work, higher preferences for college, and higher initial HK (Table 3), all of which would lead them to earn more than Type 1 individuals. Who are Type 2 individuals in terms of observables? Based on the type distribution parameters reported in Table A2, we summarize the distribution of characteristics by type in Table 4: Type 2 individuals, who account for 32% of our sample, are more likely to have higher AFQT, parental education, and parental income. The positive correlation between the unobserved advantage (being Type 2) and observed advantageous background reflects the fact that types, inferred from post-high school choices and outcomes, are outcomes from earlier parental investment.

Table 4: Characteristics by Type

	Type 1 (68%)	Type 2 (32%)
AFQT score	51.7	62.7
Pr(parent edu = HS)	56.2%	26.2%
Pr(parent edu > HS)	21.0%	67.5%
Pr(parent's income 33–66 percentile)	32.1%	25.4%
Pr(parent's income 67–100 percentile)	19.4%	45.4%

7.2 Model Fit

Table A3 shows the model fit in college-related moments. Overall, the model replicates major patterns in college enrollment, completion, college loan borrowing, and in-college labor supply reasonably well. However, the model underpredicts (overpredicts) the post- vs pre-college wage difference among 2-

year graduates (non-completers). Table A4 shows the model fit of post-college wages as measured by the auxiliary wage regression Equation (16). All model-predicted auxiliary coefficients are within the 95% confidence intervals of their data counterparts, except for the coefficient on the four-year degree dummy, which is overpredicted by the model. Table A5 shows that the model can also fit a similar auxiliary regression for assets, even though these coefficients were not targeted during estimation. Finally, Figure A1 presents the model fit for post-schooling profiles of hourly wage rates and asset holdings. Overall, the model captures these profiles fairly well, although it tends to underpredict average asset holdings during the early stages of individuals' careers.

8 Counterfactual Experiments

We conduct two sets of policy experiments. The first examines the effects of debt forgiveness, which unexpectedly removes a borrower's repayment burden upon labor market entry. This exercise is designed to quantify the ex-post welfare and behavioral distortions caused by college loan repayment, holding educational and loan choices fixed.

The second set of experiments evaluates the effect of alternative income-driven repayment (IDR) plans relative to the standard repayment plan. Unlike the debt forgiveness scenario, these IDR policies are assumed to be fully anticipated: individuals are aware of the repayment rules when making their college-related decisions. These simulations allow us to assess how repayment design shapes both pre-market behavior and post-education outcomes.

We conduct counterfactual analyses based on the estimates of both versions of the model: the Natural Borrowing Limit (NBL) and the Parameterized Borrowing Limit (PBL). *A posteriori*, both models yield similar policy implications, with the policy impacts being somewhat larger under PBL. We report results from the PBL model in the main text and those from the NBL model in Online Appendix E.

8.1 Unexpected Debt Relief

Using our estimated model, we first simulate the effect of an unexpected debt relief policy: A worker's total college loans are unexpectedly forgiven upon his entry into the labor market entry, while his education and loan choices are held fixed at their baseline levels. This simulation serves two purposes: First, it quantifies the *ex post* welfare loss from the burden of college loan repayment. Second, it helps to understand the effect of similar policies that may be implemented in rare situations.[18]

Table 5 presents how this unexpected debt forgiveness policy affects workers with college debt—the only group affected by this policy. With the removal of their college debt, these workers' first-year labor income is \$1,617 lower, age-44 income is \$246 higher, and age-45 assets are $\$1,150$ higher, relative to the levels in the baseline (the standard repayment regime). Changes in their income profiles arise

[18]For example, by July 2021, the Biden administration had canceled \$1.5 billion in student loan debt as a response to the COVID-19 pandemic.

largely from enhanced HK investment: On average, their age-45 HK stock increases by $440, relative to the baseline. In other words, the burden of college debt repayment distorts these workers toward underinvesting in their human capital on the labor market. This burden also pushes them to work 0.02 hours per week more, on average.

Table 5: Post-Schooling Effects of Debt Forgiveness for College Loan Borrowers

Outcome	Forgiveness vs. Baseline
Δ Annual Earnings (First year of labor market) ($)	-1,617
Δ Annual Earnings (Age 44, last decision period) ($)	246
Δ Assets at age 45 ($)	1,153
Δ Human Capital at age 45 ($)	440
Δ Average Weekly Hours (First 10 years of labor market)	-0.05
Δ Average Weekly Hours (All Periods)	-0.02

Notes: This table summarizes simulated changes in key post-schooling outcomes under an unexpected loan forgiveness policy, announced upon labor market entry, relative to the baseline scenario. Reported values represent differences from the baseline and are limited to college loan borrowers. All dollar amounts are in 2012 USD. Human capital is measured in dollar terms, reflecting the earnings a worker would generate from full-time employment when devoting all available time to production rather than investment.

8.2 IDR Plans

In the second set of counterfactual experiments, we study how different repayment policies shape individuals' education and career paths. We analyze two counterfactual cases. In each case, all individuals are fully aware of the repayment policy when making educational and borrowing decisions; a college loan borrower chooses, upon leaving college, between a given fixed repayment plan and a given IDR plan, as specified below.

- Case 1 (SAVE, hereafter): Upon entering the labor market, a college loan borrower chooses between the standard 10-year fixed repayment plan and an IDR plan that resembles the Saving on a Valuable Education plan (SAVE), introduced in 2023 under the Biden Administration. This plan requires a borrower to pay 5% of his discretionary income up to 20 years, after which any remaining college debt is forgiven, where discretionary income is defined as adjusted gross income (AGI) exceeding 225% of the federal poverty line (FPL).[19]

- Case 2 (RAP, hereafter) resembles the Repayment Assistance Plan announced by the Trump administration in May 2025 and scheduled to take effect for new borrowers beginning July 1, 2026. In this case, upon entering the labor market, a college loan borrower chooses (i) a fixed monthly payment plan that lasts 10 to 25 years, depending on his initial loan balance,[20] or (ii)

[19] Under SAVE, borrowers with an initial loan balance of $12,000 or less receive forgiveness after 10 years of payments. The repayment period increases by one year for each additional $1,000 borrowed up to a maximum of 20 years.

[20] The repayment period is set at 10 years for debts under $25,000; 15 years for debts between $25,000 and $50,000; 20 years for debts between $50,000 and $100,000; and 25 years for debts exceeding $100,000.

an IDR plan that requires a borrower to pay 1-10% of his income, depending on his income level, for up to 30 years before his remaining debt is forgiven. Unlike SAVE, this plan does not provide interest subsidies (unpaid interest accrues immediately), nor does it exempt a portion of income below FPL. In addition, it imposes a minimum monthly payment of $10 regardless of earnings. These features make RAP less generous than most existing IDR plans.

8.2.1 Education and Loan Choices

Panel A of Table 6 shows changes in the fraction of college enrollees, the fraction of degree holders, and graduation rates among enrollees, when the policy regime switches from the baseline to SAVE or RAP. Relative to the baseline, both SAVE and RAP lead to higher college enrollment and attainment, though the effects are modest. For example, under SAVE (the more generous IDR case), the fraction of two-year (four-year) degree holders rises by 0.84 (0.95) percentage points (ppts), whereas under RAP the increase is 0.57 (0.62) ppts. These changes reflect growth not only in enrollment but also in graduation rates conditional on enrollment. For instance, under SAVE, the graduation rate among two-year (four-year) college enrollees increases by 3.0 (1.3) ppts, compared to the baseline rate of 26.0% (53.4%).

Table 6: Education-Related Outcomes

Panel A: College Enrollment and Attainment						
		2-year			4-year	
(ppts)	Enrollment	Degree	GradRate	Enrollment	Degree	GradRate
SAVE – Baseline	0.70	0.84	3.00	0.69	0.95	1.33
RAP – Baseline	0.06	0.57	2.62	0.36	0.62	1.01
Panel B: College Loan among Enrollees and Degree Holders						
		2-year			4-year	
($)	Enrollee	Degree Holder		Enrollee	Degree Holder	
SAVE – Baseline	1,677	2,220		2,459	3,608	
RAP –Baseline	1,011	1,705		2,022	3,129	
Panel C: Consumption and Work Hours During College Years						
		Annual Consumption ($)			Weekly Work Hours in College	
SAVE – Baseline		874			-0.68	
RAP – Baseline		609			-0.60	

Notes: This table shows changes in outcomes from the baseline to SAVE or RAP, as described in the text. Panel A reports changes in college enrollment and degree attainment. "Enrollment" is the proportion of the full sample who enroll in a 2-year or 4-year college. "Degree" is the proportion of the full sample who obtain a 2-year or 4-year degree. "GradRate" is the ratio of "Degree" to "Enrollment." Panel B reports changes in the average student loan amount among enrollees and degree holders. Panel C reports changes in the average annual consumption and weekly work hours while enrolled.

Panel B shows how repayment policies affect the average loan amounts among college enrollees and degree holders. Relative to their effects on college enrollment and attainment (Panel A), repayment plans' effects on loan take-up are more salient: College students borrow considerably more when given access to an IDR plan, especially SAVE. From the baseline to SAVE, average loan amounts increase by \$1,677 among 2-year enrollees and by \$2,459 among 4-year enrollees. Under RAP, the increases are \$1,011 and \$2,022, respectively. As shown in Panel C, the increase in loans allows students to work less while in college (weekly work hours decline by 0.68 hours under SAVE and 0.60 under RAP) and consume more (annual consumption rises by \$874 under SAVE and \$609 under RAP), both channels contribute to higher in-college utility and partly explaining the increases in enrollment and graduation rates in Panel A.

8.2.2 Earnings, Assets, and Human Capital

Panel A of Table 7 presents changes in the average discounted post-education earnings up to age 44 (Column 1), assets at age 45 (Column 2), and human capital stock at age 45 (Column 3). For example, relative to the baseline, under SAVE, the discounted labor market earnings (up to age 44) increase by \$3,669, assets at age 45 by \$701, and human capital at age 45 by \$974.

Table 7: Earnings, Assets, and Human Capital by Repayment Plan (Full Sample)

Panel A: Cumulative Earnings, Assets, and Human Capital			
(\$)	Earnings (post edu. to age 44)	Assets (Age 45)	HK (Age 45)
SAVE - Baseline	3,669	701	974
RAP - Baseline	2,317	128	1178

Panel B: HK at Market Entry, Hours, and On-the-Job HK Investment			
	HK at Market Entry (\$)	Avg. Weekly Work Hrs	Avg. OTJ HK Inv. (\$)
SAVE - Baseline	641	-0.12	286
RAP - Baseline	354	-0.08	201

Notes: Each row reports changes in the average outcomes under SAVE and RAP versus the baseline. Earnings refer to the discounted sum of earnings from labor market entry up to age 44. Human capital (HK) is expressed in dollar terms and reflects the earnings a worker would obtain from full-time employment if allocating all time to production rather than investment. Labor market entry refers to the first year of work after completing schooling for college attendees and age 18 for high school graduates. Average work hours represent weekly hours averaged over the labor market period; average OTJ investment is the annual average value of foregone earnings due to time spent on skill accumulation. All values are reported in 2012 USD.

These results are primarily driven by the following factors. First, as shown in Table 6 (Panel A), when the baseline policy is replaced by an IDR policy, educational attainment increases, reflecting the role of repayment plans in one's pre-market HK accumulation. Indeed, as shown in Panel B of Table 7, the average HK upon labor market entry is \$641 (\$354) higher under SAVE (RAP). Second, although IDR plans may reduce labor supply because repayments are income-dependent, this effect is rather small (weekly work hours fall by only 0.12 under SAVE and 0.08 under RAP; Column 2 of Panel B).[21] Third, IDR plans, especially SAVE, lower repayment burden when income is low, allowing workers to invest more in their HK, as reflected in the increase in average annual on-the-job HK investment (Column 3 of Panel B).

[21] This is consistent with the small labor supply elasticities documented in the literature (Saez et al., 2012).

8.2.3 Individual Welfare

We compute, for each individual, the discounted sum of consumption equivalent variation (CEV) from $t = 1$ to T he would require under the baseline to be equally well-off as he is in a given IDR case. CEV serves as a measure of the individual welfare effect of the IDR policy relative to the baseline. Table 8 reports the cross-individual distribution (the 25^{th}, 50^{th}, and 75^{th} percentiles, as well as the mean) of these CEVs, i.e., the distribution of welfare changes across individuals.

Table 8: Changes in Individual Welfare (CEV)

($)	SAVE vs. Baseline	RAP vs. Baseline
25th Percentile	479	179
Median	7,792	4,623
75th Percentile	14,033	9,086
Mean	9,501	7,364

Notes: This table reports the distribution of changes in individual welfare under alternative repayment plans, relative to the baseline, at selected percentiles (25th, median, 75th) and the mean. Welfare changes are measured by the discounted sum of consumption equivalent variation (CEV). All values are expressed in 2012 USD.

Both SAVE and RAP lead to individual welfare gains, with SAVE yielding larger gains than RAP on average ($9,501 vs. $7,364) and at each quartile. Qualitatively, increases in individuals' welfare are expected: Under either IDR case, individuals face a more flexible set of repayment options, which raises welfare, especially in the more generous SAVE case. More subtly, the distribution of gains is right-skewed (the mean is larger than the median). This arises because IDR plans are particularly beneficial for those more likely to borrow heavily for college; in contrast, individuals far from the margin of borrowing (or college attendance) are barely affected by repayment policies.

8.2.4 Government Revenue and Social Welfare

Table 9 shows changes in discounted government revenue per person under alternative repayment plans relative to the baseline scenario. Column 1 shows changes in government tax revenue collected from individuals' lifetime earnings (up to age 62); Column 2 shows changes in government revenue (loan repayments minus amounts lent); Column 3 shows the change in government revenue, i.e., the sum of Columns 1 and 2.

To calculate tax revenue in Column 1, we need additional assumptions about individuals' choices beyond age 44 (the final decision period in our model). To be conservative, we assume that all individuals work full-time until age 60 and part-time until age 62, and that they invest in their HK between Ages 45 and 55 just to offset HK depreciation and stop investing thereafter.[22] Under these assumptions, we find that relative to the baseline, due to the large gain in tax revenue ($2,320 per

[22] Alternative, less conservative assumptions and the corresponding tax revenue calculations are presented in Online Appendix D. Notice that these assumptions affect only government tax revenue calculation, not individual welfare calculation.

Table 9: Government Revenue and Social Welfare Changes (Full Sample)

($)	ΔTax Rev.	ΔLoan Rev.	ΔGov. Rev.	CEV	ΔWelfare
SAVE – Baseline	2,320	-515	1,805	9,501	11,306
RAP– Baseline	1,012	97	1,109	7,364	8,473

Notes: Each row shows changes in government revenue and individual welfare under alternative repayment plans, relative to the baseline; all numbers are discounted to present value at $t = 1$. ΔTax Revenue is the change in total lifetime tax collection. ΔLoan Revenue is the discounted present value of loan repayment minus amounts lent (negative values indicate a loss). ΔGov. Revenue combines changes in tax and loan revenue. CEV refers to the consumption-equivalent variation, and ΔWelfare is the sum of ΔGov. Revenue and CEV. All values are expressed in 2012 USD.

person), SAVE leads to a $1,805 per person gain in government revenue, despite a loss of $515 per person in college loans. RAP yields a positive return from loan lending but a smaller tax revenue, resulting in a gain of $1,109 in government revenue.

Combining changes in government revenue (Column 3) with individual CEV (Column 4), we obtain a more comprehensive view of how repayment plans affect social welfare (Column 5): SAVE (RAP) generates an overall welfare gain of $11,306 ($8,473) per person, relative to the baseline.

Overall, our results imply that a SAVE-like plan would be too generous to be sustainable if implemented by a private lender, who would suffer from a loss. In contrast, a RAP-like plan would lead to a small positive return for a private lender. However, once individuals' lifetime income taxes are taken into account, government-run IDR plans would lead to a win-win situation: Relative to the baseline standard plan, both SAVE and RAP facilitate one's human capital investment and improve individual welfare, and they would also lead to government revenue gains. Moreover, these welfare and revenue gains are larger under the more generous SAVE plan than under RAP.

9 Conclusion

College loans can facilitate access to higher education but may also distort post-education human capital investment. To examine both effects and assess how repayment plans shape educational and career trajectories, we develop and estimate two versions of a dynamic lifecycle model of human capital investment through college education, on-the-job training, borrowing/saving, and labor supply—one with natural borrowing limits (NBL) and the other with parameterized borrowing limits (PBL).

Counterfactual simulations from both versions suggest that, relative to the standard repayment plan, income-driven repayment (IDR) plans—especially more generous ones—enable greater investment in human capital by modestly increasing college enrollment and degree completion and by facilitating on-the-job skill investment. These effects translate into higher lifetime earnings and improved individual welfare. Although generous IDR plans (e.g., SAVE) may generate negative lending profits, accounting for lifetime income taxes implies that IDR plans (e.g., SAVE and RAP) increase government revenue relative to the standard plan. In this sense, IDR policies can generate a win-win outcome for both individual welfare and government revenue.

Our framework can be extended along several dimensions. First, although individuals in our model may strategically leave part of their college loans forgiven under IDRs, we abstract from other forms of default behavior. As shown in our counterfactual simulations, students borrow more under IDRs than under the standard repayment plan. On the one hand, greater borrowing may raise default rates; on the other hand, by reducing repayment obligations at low income levels, IDRs can mitigate default risk. Incorporating default choices into our framework would allow us to quantify the relative strengths of these two forces.

Second, we abstract from the effects of limited commitment on borrowing limits. This issue is examined by Lochner and Monge-Naranjo (2011) in their study of college enrollment decisions, where borrowing constraints arise from government student loan programs and private lending in the presence of limited commitment. Building on Lochner and Monge-Naranjo (2011), an important extension of our framework would be to examine how individuals' educational and on-the-job human capital investment choices are shaped by endogenous borrowing constraints under limited commitment.

Third, given data limitations, we assume a common standard repayment plan in our baseline model, consistent with the policy environment faced by the cohorts we study. As shown in our counterfactual analysis, offering individuals additional repayment options could improve welfare. However, some argue against the coexistence of multiple IDR plans, suggesting that it may create confusion. To evaluate this concern, our framework could be extended to incorporate frictions or psychic costs associated with choosing among repayment plans. With individual-level data on repayment plan choices and career trajectories, these costs could be quantified and incorporated into the design of loan repayment policies.

Finally, we focus on a relatively homogeneous group: white men with at most a four-year college degree. Our framework could also be extended to other groups, such as women—by incorporating fertility choices—or to individuals with more advanced education by increasing the number of endogenous life stages.

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Appendix

A Model Details

A.1 Functional Form Assumptions

A.1.1 Type and Initial Human Capital

An individual's type (χ) is correlated with AFQT score, parental education (e^p) (less than high school, high school, more than high school), and parental income (inc^p) (terciles), such that

$$\Pr(\chi = 2|X) = \frac{\exp(f_1(X))}{1 + \exp(f_1(X))},$$

where

$$f_1(X) = \theta_0^\chi + \theta_1^\chi AFQT + \sum_{m=2}^{3} \theta_m^\chi I(e^p = m) + \sum_{m=2}^{3} \theta_{2+m}^\chi I(inc^p \in tercile_m).$$

An individual's initial HK level k_0 is a function of his type, AFQT score, parental education, and parental income:

$$k_0 = \theta_0^k + \theta_1^k I(\chi = 2) + \theta_2^k AFQT + \sum_{m=2}^{3} \theta_{1+m}^k I(e^p = m) + \sum_{m=2}^{3} \theta_{3+m}^k I(inc^p \in tercile_m).$$

A.1.2 Utility Functions

Utility from consumption and leisure is given by

$$u(c, h; \chi) = \upsilon_0 \frac{c^{1-\upsilon_1}}{(1-\upsilon_1)} - \lambda_{h\chi}.$$

Here, υ_0 is a scale parameter, $\frac{1}{\upsilon_1}$ is the elasticity of intertemporal substitution, $\lambda_{1\chi}$ ($\lambda_{2\chi}$) is the disutility from working part (full) time for a type-χ individual ($\lambda_{0\chi}$ is normalized to 0). The disutility from working during college is set at λ_e, regardless of the type.

Utility from college enrollment is given by

$$\psi(X, \chi, t, s_{t^e}) = b_0 + b_1 I(\chi = 2) + b_2 I(s_{t^e} = 4) + b_3 I(high\ AFQT) + b_4 I(high\ AFQT, s_{t^e} = 4) + b_5 t,$$

where $AFQT$ is high if it is above 59, the median of our sample.

A.1.3 College Graduation Probabilities

$$\pi_t = \begin{cases} 0 \text{ if } t < t^e + s_{t^e} - 1, \\ \Pi\left(X, \chi, s_{t^e}\right) = \frac{\exp(f_2(X,\chi,s_{t^e}))}{1+\exp(f_2(X,\chi,s_{t^e}))} \text{ if } t \geq t^e + s_{t^e} - 1, \end{cases}$$

where

$$f_2\left(X, \chi, s_{t^e}\right) = \rho_0 + \rho_1 I\left(\chi = 2\right) + \rho_2 I\left(\text{high } AFQT\right) + \rho_3 I\left(s_{t^e} = 4\right) + \rho_4 I\left(high\ AFQT, s_{t^e} = 4\right).$$

A.1.4 Parental Transfer Function

$$Tr\left(X, t, NC\right) = \exp\left(\iota_0 + \iota_1 NC + \iota_2 I\left(high\ AFQT\right) + \iota_3 t + \sum_{m=2}^{3} \iota_{2+m} I\left(inc^p \in tercile_m\right)\right).$$

A.1.5 Terminal Value Function

$$\begin{aligned} V^*\left(a_T, k_T; \chi, X\right) = &\sum_{m=1}^{2} \gamma_m I\left(\chi = m\right) a_T + \sum_{m=1}^{2} \gamma_{2+m} I\left(\chi = m\right) a_T^2 I\left(a > 0\right) \\ &+ \sum_{m=1}^{2} \gamma_{4+m} I\left(\chi = m\right) k_T + \sum_{m=1}^{2} \gamma_{6+m} I\left(\chi = m\right) k_T^2 + \gamma_9 a_T k_T. \end{aligned}$$

A.1.6 Labor Market HK Production and Wage Distribution

One's human capital production function is given by

$$K^J\left(k_t, i_t, h_t, g, \chi\right) = (1-\delta)k_t + \alpha_{0h} A_\chi i_t^{\alpha_1} k_t^{\alpha_2},$$

where δ is the HK depreciation rate. α_{0h} captures the differential learning efficiency by full/part-time job status, where we assume $\alpha_{00} = 0$ and normalize $\alpha_{02} = 1$, while treating α_{01} as a free parameter. A_χ is type-specific productivity; α_1, $\alpha_2 \in (0,1)$ govern the importance of investment and that of HK stock, respectively.[23]

Earnings are given by $y_t = p_{h_t} k_t (1 - i_t) e^{\eta_t}$. We model the shock as $\eta_t = \widetilde{\eta}_t - E\left(\widetilde{\eta}\right)$. Following Hai and Heckman (2017), we assume wage shocks $\widetilde{\eta}_t$ are i.i.d. draws from a gamma distribution, the probability density function of which is given by

$$f(\widetilde{\eta}_t; a, b) = \frac{1}{\Gamma(a) b^a} \widetilde{\eta}_t^{\,a-1} e^{-\widetilde{\eta}_t / b}.$$

The density function is governed by two parameters: the shape parameter a and the scale parameter b. Without loss of generality, the lowest possible $\widetilde{\eta}_t$ is normalized to 0 for all t.

[23] Similar functional forms have been used to specify human capital production functions in the literature, e.g., Uzawa (1965), Ben-Porath (1967), Rosen (1976), Ortigueira and Santos (1997), and Heckman et al. (1998a).

A.2 Natural Borrowing Limit

In deriving the natural borrowing limit, Hai and Heckman (2017) consider the consumption level that makes an individual indifferent between $h_t \in \{1, 2\}$ and $h_t = 0$ such that, under the most unfavorable possible income shocks, earnings beyond this consumption level can be enforced to be paid back to the lender. We extend this concept to account for individuals' optimal choices of employment $h \in \{0, 1, 2\}$ and investment $i \in [0, 1]$. Denote $C_t^{ev}(h, i; l_{t^o}, \chi, k_t)$ as the (h, i)-specific consumption compensation at time t for an individual with state variables (l_{t^o}, χ, k_t), which is the consumption level that makes him indifferent between choosing (h, i) and not working $(h = 0)$ at t (before the realization of transitory labor supply taste shocks).$C_t^{ev}(h, i; l_{t^o}, \chi, k_t)$ is implicitly defined by

$$\begin{aligned} & u(C_t^{ev}(h, i; l_{t^o}, \chi, k_t), h; \chi) + \beta E \left[V_{t+1}\left(\Omega_{t+1} | \Omega_t, a_{t+1} - l_{t+1} = B_t(l_{t^o}, k_{t+1}, \chi), k_{t+1} = (1-\delta)k_t + \Upsilon\left(h, g, \chi\right) i^{\alpha_1} k_t^{\alpha_2}\right)\right] \\ & = u(\underline{c}, h = 0; \chi) + \beta E \left[V_{t+1}\left(\Omega_{t+1} | \Omega_t, a_{t+1} - l_{t+1} = B_t(l_{t^o}, k_{t+1}, \chi), k_{t+1} = (1-\delta)k_t\right)\right]. \end{aligned} \tag{17}$$

We define the endogenous borrowing limit at t recursively by the following:

$$\begin{aligned} & u(C_t^{ev}(h, i; l_t, \chi, k_t), h; \chi) + \beta E \left[V_{t+1}\left(\Omega_{t+1} | \Omega_t, a_{t+1} - l_{t+1} = B_t(l_{t+1}, k_{t+1}, \chi), k_{t+1} = (1-\delta)k_t + \Upsilon\left(h, g, \chi\right) i^{\alpha_1} k_t^{\alpha_2}\right)\right] \\ & = u(\underline{c}, h = 0; \chi) + \beta E \left[V_{t+1}\left(\Omega_{t+1} | \Omega_t, a_{t+1} - l_{t+1} = B_t(l_{t+1}, k_{t+1}, \chi), k_{t+1} = (1-\delta)k_t\right)\right]. \end{aligned} \tag{18}$$

We define the endogenous borrowing limit at t recursively by the following:

$$B_{t-1}(l_t, k_t, \chi) = \frac{B_t(l_{t+1}, k_{t+1}, \chi) - \max\{0, p_{\tilde{h}} k_t \left(1 - \tilde{\imath}\right) e^{\underline{\eta}} - C_t^{ev}(\tilde{h}, \tilde{\imath}; l_t, \chi, k_t)\}}{1 + r^b} \tag{19}$$

$$\{\tilde{h}, \tilde{\imath}\} = \arg \max_{h \in \{0,1,2\}, i \in [0,1]} \{I(h > 0) \left[p_h k_t \left(1 - i\right) e^{\underline{\eta}} - C_t^{ev}(h, i; l_t, \chi, k_t)\right]\}\} \tag{20}$$

$$k_{t+1} = (1-\delta)k_t + \Upsilon\left(h, g, \chi\right) \tilde{\imath}^{\alpha_1} k_t^{\alpha_2}, \tag{21}$$

where $\underline{\eta}$ is the most unfavorable income shock.[24] For the last period, we set $B_T(\cdot)$ at the fifth percentile of the asset distribution among those aged 44 to 46 in our sample, which is $-\$1,215$. Then we calculate the natural borrowing limit from $t = T$ to $t = age_0$ using equations (19) to (21) recursively.

A.3 Stage Variables

State variables common to all stages include X, χ, t, non-college loan assets a_t^n, college loan l_t, and HK stock k_t. Stage-specific additional state variables are the following:

- Stage A: shocks to college enrollment choices (ζ_t), labor supply choices (ϵ_t), and wages (η_t).
- Stage B: college entry age t^e, college type s_{t^e}, and shocks to college dropout choices (ζ_t) and in-college labor supply and loan choices (ε_t).

[24] These equations imply that if $\left(p_h k_t \left(1 - i\right) e^{\underline{\eta}} - C_t^{ev}(h, i; l_0, \chi, k_t)\right) < 0$ for $h > 0$, then $\hat{h} = 0$ and $B_t(l_0, k_t, \chi) = \frac{B_{t+1}(l_0, k_{t+1}, \chi)}{1+r^b}$.

- Stage C: first post-college period t^o and shocks to labor supply choices (ϵ_t) and wages (η_t).

B Pre-Set Parameters

We pre-set the following parameters, as reported in Table A1.

1. We set the risk aversion coefficient $\rho = 2.0$ as in, for example, Lochner and Monge-Naranjo (2011), Johnson (2013), Hai and Heckman (2017) and Hai and Heckman (2019).

2. Following Hai and Heckman (2017), we calculate the out-of-college consumption floor ($\underline{c}$) as the average amount of means-tested transfers (including food stamps, AFDC, and WIC) among recipients in NLSY79;[25] While in college, the consumption floor is set to be the cost of room and board, \$4,920 (\$5,366) for a two-year (four-year) college.

3. We set the interest rate for college loans (r^c) at the average real interest rate of Stafford loans between 2001 and 2005 after college; while in college, the interest rate is set to be 0 because during our sample period, most student loans are subsidized.[26] We set the interest rate for borrowing $\left(r^b\right)$ at the average real prime rate between 2001 and 2007 plus a 2% risk premium, and the interest rate for savings (r^a) at the average real interest rate on one-year U.S. government bonds from 2001 to 2007.

4. For the income tax schedule $\tau(y_t)$, we adopt the functional form and parameter values from Gouveia and Strauss (1994) and Imrohoroglu and Kitao (2012) such that

$$\tau(y_t) = \tau_0 \left(y_t - (y^{-\tau_1+\tau_2})^{-1/\tau_1} \right),$$

   where τ_0 measures the average tax rate, τ_1 governs tax progressiveness, and τ_2 is a scale parameter.[27]

5. Wage rates while in college: average earnings for college enrollees who work in our sample. It is calculated as \$13.76.

6. College tuitions are based on averages for the sample years from IPEDS data (Source: NECD data). The tuition per enrollment year is calculated as \$1,481 for two-year colleges and \$4,918 for four-year colleges. Grants are derived from NLSY79 data, categorized by college type and parent income terciles. The average grants by parental income tercile for two-year colleges are \$1,426, \$1,011, and \$491, while for four-year colleges, they are \$2,566, \$1,443, and \$911, respectively.

[25] Hai and Heckman (2017) use NLSY97 and we use NLSY79, but our $\underline{c}$ is similar to theirs, which is reported as \$2,800 in 2004 USD (\$3,403 in 2012 USD).

[26] Though unsubsidized borrowing grew recently, subsidized loans remained the predominant type through the late '90s and early 2000s, during the college years of our sample cohort. In 1995–96, approximately 22% of undergraduates received subsidized Stafford loans, while only 10% received unsubsidized loans ((Wei and Berkner, 2008)).

[27] This functional form is proposed by Gouveia and Strauss (1994) and has been employed in many quantitative studies including Castaneda et al. (2003), Conesa and Krueger (2006), and Conesa et al. (2009).

7. Government college loan limit: The college loan limits, which affect the borrowing limits in school, are based on Stafford Loan limits during our sample years. (Note: Following Hai and Heckman (2017), we specify both annual and total loan limits, making adjustments to align with our sample years.) Specifically, the annual borrowing limits ($\bar{l}^{gov}$), adjusted using enrollment weights, are \$2,223 (grade 13), \$2,316 (grade 14), and \$2,500 (grade 15 and above). The cumulative borrowing limit for undergraduates ($\bar{L}^{gov}$), calculated using enrollment weights, is \$9,268.

Table A1: Preset Parameters

Discount rate	β	0.95
Risk averse coefficient	ρ	2.00
Interest rate for college loans, borrowing, and saving	$\{r^c, r^b, r^a\}$	$\{2.2\%, 5.9\%, 0.9\%\}$
Consumption floor	$\underline{c}$	$\$3,317$
Income taxation	$\{\tau_0, \tau_1, \tau_2\}$	$\{0.258, 0.726, 6.158\}$
Wage rates in college		\$13.76
Net tuition	$NC\,(s=2, X)$	$\{55, 470, 990\}$
	$NC\,(s=4, X)$	$\{2352, 3475, 4007\}$
Government Annual Borrowing Limit	$\bar{l}^{gov}(e=13)$	\$2223
	$\bar{l}^{gov}(e=14)$	\$2316
	$\bar{l}^{gov}(e\geq 15)$	\$2500
Government Aggregate Borrowing Limit	$\bar{L}^{gov}$	\$9268

Table A2: Other Parameter Estimates for PBL

H. Type distribution: $\Pr(\chi = 2) = \exp(X\theta^{\chi}) / (1 + \exp(X\theta^{\chi}))$		
Constant term (θ_0^{χ})	-2.792	(0.068)
AFQT score (θ_1^{χ})	0.009	(0.001)
Parent's education = HS (θ_2^{χ})	0.082	(0.003)
Parent's education > HS (θ_3^{χ})	2.094	(0.060)
Parents' income (33-66 percentile) (θ_4^{χ})	0.569	(0.109)
Parents' income (67-100 percentile) (θ_5^{χ})	1.579	(0.082)
I. Initial human capital (k_0)		
Constant term (θ_0^k)	1.705	(0.013)
Type 2 (θ_1^k)	0.241	(0.005)
AFQT (θ_2^k)	0.002	(0.001)
Parent's education = HS (θ_3^k)	0.362	(0.005)
Parent's education > HS (θ_4^k)	2.272	(0.079)
Parents' income (33-66 percentile) (θ_5^k)	1.125	(0.044)
Parents' income (67-100 percentile) (θ_6^k)	2.474	(0.029)
J. Variance of Preference Shocks		
Utility scale parameter (υ)	2.337	(0.013)
Std. Dev. of college preference shocks	0.924	(0.016)
Std. Dev. of in-college loan-work preference shocks	0.929	(0.114)
K. Terminal Value (at age 45)		
Assets (Type 1)(γ_1)	6.569	(0.268)
Assets^2 (Type 1) (γ_2)	-0.037	(0.001)
Asset (Type 2) (γ_3)	9.466	(0.276)
Asset^2 (Type 2) (γ_4)	-0.144	(0.005)
Human capital (Type 1) (γ_5)	2.862	(0.088)
Human capital^2 (Type 1) (γ_6)	-0.029	(0.001)
Human capital (Type 2) (γ_7)	9.473	(0.105)
Human capital^2 (Type 2) (γ_8)	-0.040	(0.001)
Assets $\times$ human capital (γ_9)	-0.033	(0.002)
L. Wage Distribution		
Shape of Gamma Distribution (a)	46.415	(1.861)
Scale of Gamma Distribution (b)	0.064	(0.002)
M. Credit constraints (PBL): $\underline{b}_{t+1} = -\exp[\phi_0 + \phi_1 \text{age}_t + \phi_2 k_t + \phi_3 coll]$		
Constant term (ϕ_0)	-1.026	(0.020)
Age (ϕ_1)	0.058	(0.001)
Human capital (ϕ_2)	0.009	(0.001)
In College (ϕ_3)	0.153	(0.007)

Table A3: Model Fit: College-Related Moments

	Data	Model
2-year College Enrollees (%)	17.50	21.07
4-year College Enrollees (%)	41.50	42.69
2-year College Completion Rate (%)	26.70	26.03
4-year College Completion Rate (%)	58.60	53.43
2-year College On-time Completion Rate (%)	17.00	13.97
4-year College On-time Completion Rate (%)	33.10	35.34
College Loans|Enrollment in 2-year ($1,000)	1.32	1.63
College Loans|Enrollment in 4-year ($1,000)	6.16	6.49
College Loans (Std. Dev)|Enrollment ($1,000)	8.33	4.27
Working While Enrolled (%)	67.20	69.37
Gap Years	0.90	1.02
Average Years in 2-Year College	2.39	1.87
Average Years in 4-Year College	4.98	4.49
Post- vs Pre-college Wage Diff. (2-year Dropouts)	4.82	7.29
Post- vs Pre-college Wage Diff. (2-year Graduates)	11.95	9.67
Post- vs Pre-college Wage Diff. (4-year Dropouts)	5.26	4.36
Post- vs Pre-college Wage Diff. (4-year Graduates)	14.78	13.06
Moments for High AFQT Subgroup	Data	Model
2-year College Enrollees (%)	16.53	11.96
4-year College Enrollees (%)	63.83	70.95
College Completion Rate (%)	59.20	52.84
College Loans|Enrollment ($1,000)	4.57	4.38
Working While Enrolled (%)	69.00	63.90

Table A4: Model Fit: Post-College Wage Regression

	Data		Model
	Coefficient	95% CI	
Labor market experience (yrs)	4.25	(3.50, 5.00)	4.36
Labor market experience $(\text{yrs})^2$	-0.11	(-0.14, -0.07)	-0.07
Labor market experience (yrs, full-time)	1.38	(1.00, 1.76)	1.46
Total amount of college loan	1.65	(-0.31, 3.61)	1.98
Experience × large loan	0.36	(-0.08, 0.81)	-0.03
Experience × first 10 yrs	0.53	(0.08, 0.98)	0.25
Experience × first 10 yrs × loan	-1.04	(-1.97, -0.11)	-0.43
4-year college degree	16.62	(14.09, 19.14)	22.00
Full-time	20.67	(16.94, 24.39)	24.29

Notes: Other controls include dummy variables for individuals whose parental education is high school, those whose parental education exceeds high school, those whose parental income falls in the second tercile, those whose parental income is in the third tercile, and those with AFQT scores above the median.

Table A5: Model Fit: Post-College Asset Regression (Not Targeted)

	Data		Model (PBL)
	Coefficient	95% CI	
Labor market experience (yrs)	0.46	(0.42, 0.49)	0.70
Total amount of college loan	-0.72	(-1.00, -0.44)	-1.00
Experience $\times$ loan	0.02	(-0.05, 0.10)	0.08
Experience $\times$ first 10 yrs	-0.03	(-0.09, 0.03)	-0.10
Experience $\times$ first 10 yrs $\times$ loan	-0.09	(-0.23, 0.05)	-0.10

Notes: This table compares coefficients from the data regression to those implied by the structural model (PBL specification). Additional controls include dummy variables for attending a four-year college, full-time employment, parental education at the high school level, parental education beyond high school, parental income in the second and third terciles, and AFQT scores above the median. The data coefficients are reported with 95% confidence intervals.

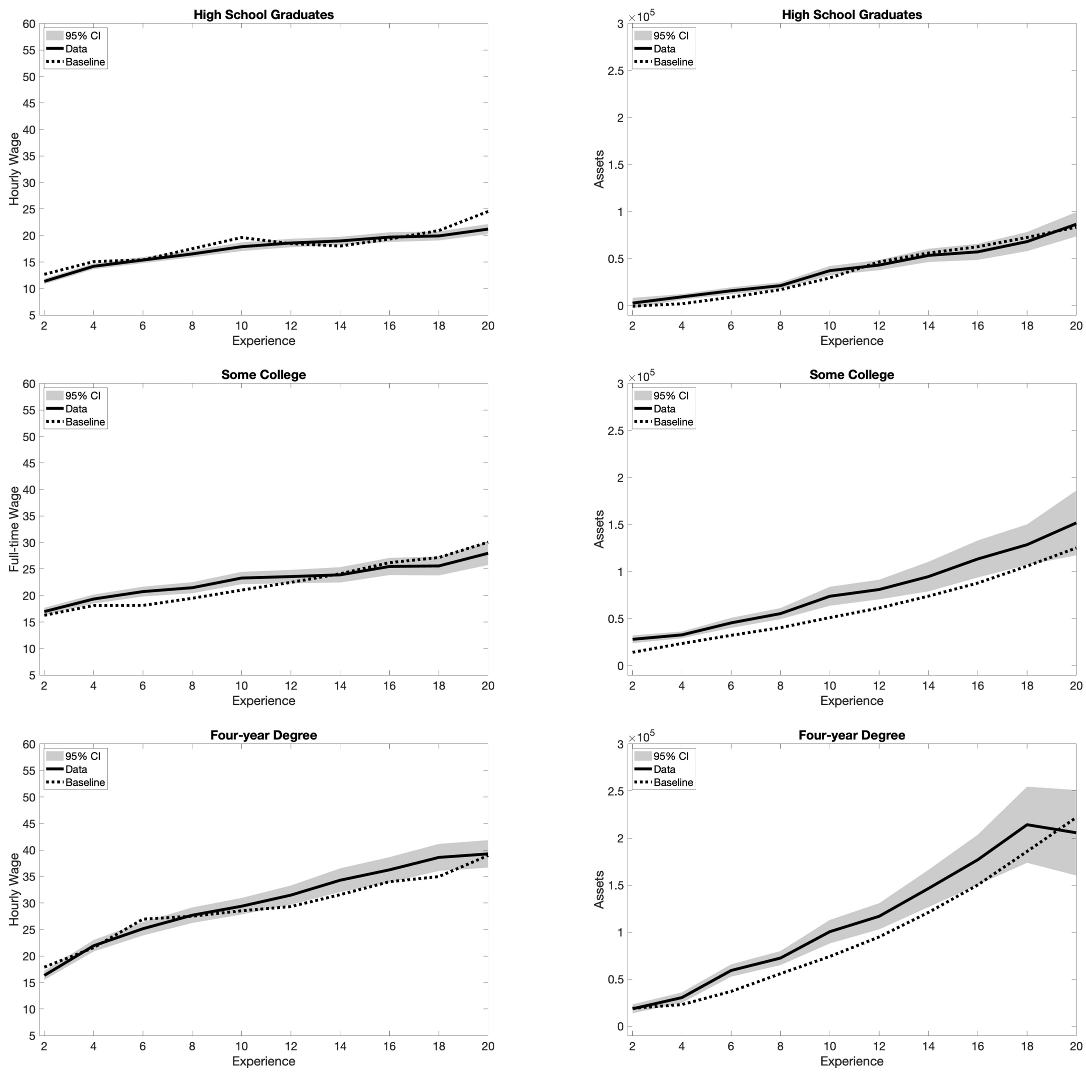

Figure A1: Model Fit: Wage and Asset Profiles by Education

Notes: The horizontal axis represents potential labor market experience, measured as years since leaving school for each education group (high school graduates, some-college educated, and four-year degree holders). Solid lines denote observed data, shaded areas represent 95% confidence intervals of the data, while dotted lines represent model predictions. All dollar amounts are reported in 2012 USD.

College Loans and Human Capital Investment (Online Appendix)

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C Model Solution

We solve the model numerically by backward induction. Individual heterogeneity at time t in the model is characterized by (a_t, k_t, X, χ). The variables are discretized as follows: in solving the model, the asset space (a_t) is discretized into 18 grid points, while in simulating the model, agents are allowed to choose from a finer grid with 30 asset points; the corresponding value functions are obtained by linear interpolation. The human capital levels (k_t) are discretized using five points. The amounts of unpaid loans and additional loans are both discretized using five points. With two unobserved types, this classification amounts to 4,500 possible state points that represent individual heterogeneity. With the state space discretized, we can solve the model for each individual who belongs to one of mutually exclusive groups defined by (a_t, k_t, X, χ).

Continuous choice variables (asset (a) and HK investment (i)) are discretized. An individual can choose the asset level in the next period a_{t+1} from the set $\{\underline{a},...,\overline{a}\}$, subject to the borrowing limit $\underline{b}_{t+1}$. We need to interpolate the value function since the HK level and/or the unpaid loan level in the next period could be at a value between the value functions evaluated on the grid. When the new level of HK associated with a chosen amount of investment is at a value between two grid points, we apply linear interpolation.

C.1 Further Details

Since the preference shocks follow an i.i.d. Type I extreme value distribution, the decision problem at time t, given $\{a_{t+1}, c_t, i_t, \eta_t\}$, can be written in recursive form as

$$V(\Omega_t, \epsilon \big| a_{t+1}, c_t, i_t, \eta_t) = \max_h \left(\tilde{v}(x_t, h \big| a_{t+1}, c_t, i_t, \eta_t) + \epsilon_{th}\right), \tag{C1}$$

where

$$\tilde{v}(x_t, h) = u\left(c_t, h_t, \epsilon_t; \chi\right) + \beta E[V_{t+1}\left(\Omega_{t+1}\right)]. \tag{C2}$$

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Denote $\bar{v}(x_t) = E_\epsilon[\tilde{v}(x,\epsilon)]$, where x consists of all the necessary state variables. Following McFadden (1974) and Rust (1987), we have

$$\bar{v}(x_t) = \bar{\gamma} + \log\left(\sum_{h=0}^{2} \exp\left(\tilde{v}(x_t,h)\right)\right) \tag{C3}$$

where $\bar{\gamma}$ is the Euler constant.

Using the above solution, the value function can now be expressed by

$$E[V_{t+1}(\Omega_{t+1}|a_{t+2}, c_{t+1}, i_{t+1})] = \int \left[\bar{v}(x_{t+1}|\eta_{t+1})\right] dF\left(\eta_{t+1}\right). \tag{C4}$$

The integrals over wage shocks η are calculated by approximation through Monte Carlo integration.

D Government Budget under Different Assumptions

We evaluate the impact of different counterfactual scenarios on the government budget under four alternative assumptions about the evolution of human capital and work status beyond T (age 45) until retirement (age 62). The results are presented in Table D1. The four cases are defined as follows:

- **Case 1 (the case used in the main text):** Individuals invest enough to maintain their human capital until age 55, then stop investing, and work full time until age 60 and part time for the final two years.
- **Case 2:** Individuals stop investing in human capital after age 45 and work full time until age 60 and part time for the final two years.
- **Case 3:** Individuals invest enough to maintain their human capital until age 50, then stop investing, and work full time until age 60 and part time for the final two years.
- **Case 4:** Individuals invest at a constant rate of 0.1 until age 55, then stop investing, and work full time until age 60 and part time for the final two years.

Table D1: Government Budget (PBL) – Other Scenarios (Present Value)

	SAVE			RAP		
	ΔTax Rev	ΔBudget	ΔCEV + ΔBudget	ΔTax Rev	ΔBudget	ΔCEV + ΔBudget
Case 1	2,320	1,805	11,306	1,012	1,109	8,473
Case 2	2,413	1,898	11,399	1,052	1,149	8,513
Case 3	2,379	1,865	11,365	1,036	1,133	8,497
Case 4	2,372	1,857	11,358	1,036	1,133	8,497

E Results for Natural Borrowing Limits (NBL)

In this section, we present results for the version of the model with natural borrowing limits (NBL), focusing on parameter estimates, model fit, and counterfactual outcomes.

E.1 Parameter Estimates (NBL)

Table E1 reports the main structural parameter estimates, with bootstrapped standard errors in parentheses. Panel A presents the parameters governing the human capital (HK) production function. The annual depreciation rate of human capital is approximately 1.6 percent. The elasticity of HK production with respect to investment is about 1.01, while the elasticity with respect to the existing HK stock is about 0.85. Moreover, Type-2 individuals are estimated to be more efficient at producing human capital than Type-1 individuals. Consistent with the PBL case, part-time employment reduces the productivity of human capital accumulation: production while working part-time is only about 78 percent as effective as under full-time employment. Panel B further shows that, for the same quantity of human capital supplied to the labor market, part-time workers earn only about 35 percent of the annual wage received by full-time workers.

Panel C of Table E1 reports estimates of disutility from work. Type-2 individuals face lower disutility relative to Type-1 individuals, both for part-time and full-time work. Panel D focuses on college preferences. The results indicate that individuals with higher AFQT scores and Type-2 individuals derive greater utility from attending college. College preferences decline with age, and four-year colleges are valued more highly, particularly among Type-2 individuals. Panel E presents the determinants of graduation probabilities. Higher AFQT and Type-2 individuals are more likely to complete college. On average, a four-year college education carries a higher risk of dropout relative to two-year programs, though this penalty is smaller for Type-2 individuals. Panel F summarizes human capital gains associated with college outcomes. Although partial completion of college modestly increases human capital (1.27 for two-year dropouts and 1.90 for four-year dropouts), the gains from completing college are substantially larger (3.81 for two-year completion and 4.54 for four-year completion). Finally, Panel G shows that annual parental transfers increase with tuition and family income, decrease with student age, and are somewhat larger for four-year college enrollees.

Table E2 presents additional parameter estimates for the NBL case. Two observations are worth noting. First, unlike in the PBL case—where the parameters governing borrowing constraints are estimated—borrowing constraints are endogenously determined under NBL. Consequently, Panel M does not appear in Table A2. Second, the signs of the coefficients in Panels H through L are identical to those in Table A2, and their magnitudes are very similar. This similarity suggests that behavioral responses are largely consistent across the two borrowing environments.

Finally, Table E3 summarizes the distribution of observed characteristics by unobserved type. Consistent with the PBL case, we find a strong positive correlation between being Type 2—interpreted as having unobserved advantages—and coming from a more favorable observable background, such as higher parental education or income. This pattern provides indirect evidence that early-life parental investment contributes to the development of unobserved traits. The persistence of this relationship across different credit environments supports the interpretation that type reflects a combination of innate ability and early inputs that shape long-run outcomes.

E.2 Model Fit (NBL)

Table E4 reports the targeted college-related moments. Overall, the model reproduces the main patterns in college enrollment, completion, student loan borrowing, and in-college labor supply. Nonetheless, it underpredicts four-year college completion rates and overpredicts the incidence of working while enrolled, particularly among high-AFQT students. The model also tends to underpredict the wage gains of two-year graduates relative to non-completers, while slightly overpredicting the corresponding gap for dropouts.

Table E1: Parameter Estimates for NBL

A. HK production: $k_{t+1} = (1-\delta)k_t + \alpha_{0h} A_\chi i_t^{\alpha_1} k_t^{\alpha_2}$		
Skill depreciation rate (δ)	0.016	(0.001)
Elasticity w.r.t. investment (α_1)	1.012	(0.020)
Elasticity w.r.t. human capital stock (α_2)	0.850	(0.008)
Type 1 factor (A_1)	0.097	(0.001)
Type 2 factor (A_2)	0.148	(0.007)
Part-time factor (α_{01})	0.782	(0.016)
B. Skill price for part-time jobs (p_1)		
	0.349	(0.006)
C. Disutility from Work		
Part-time work (Type 1) (λ_{11})	0.837	(0.023)
Part-time work (Type 2) (λ_{12})	0.086	(0.002)
Full-time work (Type 1) (λ_{21})	0.912	(0.014)
Full-time work (Type 2) (λ_{22})	0.488	(0.010)
Work during college (λ_e)	1.107	(0.075)
D. College Preference		
Constant term (ψ_0)	-39.163	(0.830)
AFQT score (ψ_1)	4.384	(0.081)
Type 2 (ψ_2)	10.774	(0.747)
Time (ψ_3)	-2.216	(0.063)
4-year college (ψ_4)	7.237	(0.079)
4-year college for Type 2 (ψ_5)	3.097	(0.048)
E. Graduation Probabilities		
Constant term (ρ_0)	-1.063	(0.019)
AFQT score (ρ_1)	2.635	(0.080)
Type 2 (ρ_2)	0.775	(0.033)
4-year college (ρ_3)	-0.848	(0.014)
4-year college for Type 2 (ρ_4)	0.524	(0.010)
F. Human capital gain upon leaving school: $\kappa(s_t^e)$		
Dropping Out from 2-year ($\kappa_0(s_t^e = 2)$)	1.270	(0.026)
Completing 2-year ($\kappa_1(s_t^e = 2)$)	3.809	(0.045)
Dropping Out from 4-year ($\kappa_0(s_t^e = 4)$)	1.894	(0.049)
Completing 4-year ($\kappa_1(s_t^e = 4)$)	4.537	(0.040)
G. Parental Transfer		
Constant term (ι_0)	1.032	(0.055)
Tuition (ι_1)	0.587	(0.016)
Age (ι_2)	-0.101	(0.003)
Parents' income (33–66 percentile) (ι_3)	0.203	(0.005)
Parents' income (67–100 percentile) (ι_4)	0.587	(0.052)
4-year college (ι_5)	0.153	(0.002)

Table E2: Parameter Estimates for NBL (cont.)

H. Type distribution		
Constant term (θ_0^{χ})	-2.676	(0.073)
AFQT score (θ_1^{χ})	0.009	(0.001)
Parent's education = HS (θ_2^{χ})	0.083	(0.001)
Parent's education > HS (θ_3^{χ})	1.981	(0.062)
Parents' income (33–66 percentile) (θ_4^{χ})	0.603	(0.043)
Parents' income (67–100 percentile) (θ_5^{χ})	1.649	(0.127)
I. Initial human capital (k_0)		
Constant term (θ_0^k)	1.615	(0.029)
Type 2 (θ_1^k)	0.219	(0.003)
AFQT (θ_2^k)	0.002	(0.001)
Parent's education = HS (θ_3^k)	0.378	(0.016)
Parent's education > HS (θ_4^k)	2.201	(0.075)
Parents' income (33–66 percentile) (θ_5^k)	1.078	(0.053)
Parents' income (67–100 percentile) (θ_6^k)	2.101	(0.079)
J. Variance of Preference Shocks		
Utility scale parameter (υ)	2.399	(0.032)
Std. Dev. of college preference shocks	1.229	(0.075)
Std. Dev. of in-college loan-work preference shocks	1.020	(0.133)
K. Terminal Value (at age 45)		
Asset (Type 1) (γ_1)	6.282	(0.153)
Asset^2 (Type 1) (γ_2)	-0.040	(0.001)
Asset (Type 2) (γ_3)	6.362	(0.293)
Asset^2 (Type 2) (γ_4)	-0.136	(0.002)
Human capital (Type 1) (γ_5)	3.503	(0.157)
Human capital^2 (Type 1) (γ_6)	-0.002	(0.001)
Human capital (Type 2) (γ_7)	10.581	(0.236)
Human capital^2 (Type 2) (γ_8)	-0.039	(0.001)
Asset × human capital (γ_9)	-0.034	(0.001)
L. Wage Distribution		
Shape of Gamma Distribution (a)	48.033	(2.703)
Scale of Gamma Distribution (b)	0.067	(0.002)

Table E5 reports the targeted moments for post-college wages, as estimated using the auxiliary wage regression. All model-predicted coefficients share the same sign as in the data regression, although some estimates lie outside the 95 percent confidence intervals of their empirical counterparts.

Taken together, the results indicate that the model fits the data well and captures most key empirical patterns. Despite the model's somewhat weaker performance in the wage regression, the model continues to replicate the core wage dynamics, including returns to labor market experience and education.

Table E3: Characteristics by Type (NBL)

	Type 1 (65%)	Type 2 (35%)
AFQT score	51.4	62.4
Pr(parent edu = HS)	56.1%	28.6%
Pr(parent edu > HS)	20.9%	64.2%
Pr(parent's income 33–66 percentile)	32.0%	26.0%
Pr(parent's income 67–100 percentile)	18.4%	45.5%

Table E4: Model Fit: College-Related Moments (NBL)

	Data	Model
2-year College Enrollees (%)	17.50	20.95
4-year College Enrollees (%)	41.50	42.03
2-year College Completion Rate (%)	26.70	28.58
4-year College Completion Rate (%)	58.60	47.51
2-year College On-time Completion Rate (%)	17.00	18.15
4-year College On-time Completion Rate (%)	33.10	33.16
College Loans|Enrollment in 2-year ($1,000)	1.32	1.18
College Loans|Enrollment in 4-year ($1,000)	6.16	5.75
College Loans (Std. Dev.)|Enrollment ($1,000)	8.33	4.07
Working While Enrolled (%)	67.20	89.13
Gap Years	0.90	0.62
Average Years in 2-Year College	2.39	1.64
Average Years in 4-Year College	4.98	4.44
Post- vs Pre-college Wage Diff. (2-year Dropouts)	4.82	7.84
Post- vs Pre-college Wage Diff. (2-year Graduates)	11.95	8.73
Post- vs Pre-college Wage Diff. (4-year Dropouts)	5.26	6.31
Post- vs Pre-college Wage Diff. (4-year Graduates)	14.78	18.60
Moments for High AFQT Subgroup		
2-year College Enrollees (%)	16.53	7.46
4-year College Enrollees (%)	63.83	66.34
College Completion Rate (%)	59.20	49.94
College Loans|Enrollment ($1,000)	4.57	3.57
Working While Enrolled (%)	69.00	85.70

E.3 Counterfactual Results (NBL)

This subsection presents counterfactual results under the natural borrowing limit (NBL). As in the PBL case, we first analyze the effects of an unexpected debt relief policy, followed by results for alternative income-driven repayment (IDR) schemes.

Table E5: Model Fit: Post-College Wage Regression (NBL)

	Data		Model
	Coefficient	95% CI	
Labor market experience (yrs)	4.25	(3.50, 5.00)	3.31
Labor market experience (yrs)^2	-0.11	(-0.14, -0.07)	-0.01
Labor market experience (yrs, full-time)	1.38	(1.00, 1.76)	1.27
Total amount of college loan	1.65	(-0.31, 3.61)	7.13
Experience × large loan	0.36	(-0.08, 0.81)	0.05
Experience × first 10 yrs	0.53	(0.08, 0.98)	0.87
Experience × first 10 yrs × loan	-1.04	(-1.97, -0.11)	-0.14
4-year college degree	16.62	(14.09, 19.14)	25.88
Full-time	20.67	(16.94, 24.39)	47.72

Notes: Other controls include dummy variables for individuals whose parental education is high school, those whose parental education exceeds high school, those whose parental income falls in the second tercile, those whose parental income is in the third tercile, and those with AFQT scores above the median.

Table E6: Model Fit: Post-College Asset Regression (Not Targeted) (NBL)

	Data		Model (NBL)
	Coefficient	95% CI	
Labor market experience (yrs)	0.46	(0.42, 0.49)	0.69
Total amount of college loan	-0.72	(-1.00, -0.44)	-0.78
Experience × loan	0.02	(-0.05, 0.10)	0.17
Experience × first 10 yrs	-0.03	(-0.09, 0.03)	-0.06
Experience × first 10 yrs × loan	-0.09	(-0.23, 0.05)	-0.18

Notes: This table compares coefficients from the data regression to those implied by the structural model (NBL specification). Additional controls include dummy variables for attending a four-year college, full-time employment, parental education at the high school level, parental education beyond high school, parental income in the second and third terciles, and AFQT scores above the median. The data coefficients are reported with 95% confidence intervals.

E.3.1 Unexpected Debt Relief

We begin by simulating an unexpected debt relief policy in which all outstanding student loans are forgiven upon labor market entry, while education and loan choices remain fixed at their baseline levels. The results are summarized in Table E7.

Table E7 shows the impact of this policy on borrowers with outstanding student debt—the only group directly affected. Debt forgiveness reduces their first-year labor income by about $1,470, increases their income at age 44 by $355, and raises their asset holdings at age 45 by $388, relative to the baseline repayment regime. These shifts primarily reflect higher investment in human capital: by age 45, average human capital rises by roughly $781. Put differently, the obligation to repay student debt distorts workers toward underinvesting in human capital during their careers. In addition, debt repayment induces slightly greater labor supply in the baseline, with affected individuals working about 0.02 more hours per week on average.

Table E7: Post-Schooling Effects of Debt Forgiveness for College Loan Borrowers (NBL)

Outcome	Forgiveness vs. Baseline
Δ Annual Earnings (First year of labor market) ($)	-1,470
Δ Annual Earnings (Age 44, last decision period) ($)	355
Δ Asset at Age 45 ($)	388
Δ Human Capital at Age 45 ($)	781
Δ Average Weekly Hours (First 10 years of labor market)	-0.024
Δ Average Weekly Hours (All Periods)	-0.022

Notes: This table summarizes simulated changes in key post-schooling outcomes under an unexpected loan forgiveness policy, announced upon labor market entry, relative to the baseline scenario. Reported values represent differences from the baseline and are limited to college loan borrowers. All dollar amounts are in 2012 USD. Human capital is measured in dollar terms, reflecting the earnings a worker would generate from full-time employment when devoting all available time to production rather than investment.

E.3.2 IDR plans

In the second set of counterfactual experiments, we study how alternative repayment policies influence individuals' education and career choices. We consider two policy environments. In each case, individuals are fully informed about the repayment regime when making education and borrowing decisions. Upon leaving college, a borrower chooses between the standard fixed repayment plan and the IDR option, as described in the main text.

Education and Loan Choices

Panel A of Table E8 compares enrollment, degree attainment, and graduation rates across repayment plans. Relative to the baseline, both SAVE and RAP modestly raise college attainment, with SAVE generating slightly larger increases. For example, the share of two-year (four-year) degree holders increases by 0.57 (0.71) percentage points under SAVE, compared to 0.19 (0.26) under RAP. Overall enrollment effects are small: two-year enrollment falls slightly under both plans, while four-year enrollment rises modestly, indicating a shift from two-year to four-year programs. Graduation rates (degrees conditional on enrollment) improve for two-year programs but decline slightly for four-year programs, mostly due to the selection of weaker students into 4-year colleges.

Panel B reports average loan amounts among enrollees and degree holders. The effects on borrowing are more pronounced than those on attainment. For example, from the baseline to SAVE, an average two-year (four-year) enrollee borrows $1,103 ($1,598) more. Panel C shows that these additional loans allow students to work fewer hours in college and consume more.

Earnings, Assets and Human Capital

Panel A of Table E9 reports average discounted lifetime earnings through age 44, assets at age 45, and human capital at age 45. Outcomes are consistently higher under SAVE than RAP. For instance, average discounted earnings increase by $9,744 under SAVE compared to only $4,995 under RAP. Similarly, assets at age 45 rise by $1,130 under SAVE versus $110 under RAP, while human capital at age 45 grows by $951 under SAVE and $539 under RAP.

Table E8: Education-Related Outcomes (NBL)

Panel A: College Enrollment and Attainment						
		2-year			4-year	
(ppts)	Enrollment	Degree	GradRate	Enrollment	Degree	GradRate
SAVE – Baseline	-0.14	0.57	2.93	1.68	0.71	-0.20
RAP – Baseline	-0.17	0.19	1.14	0.80	0.26	-0.29
Panel B: College Loan among Enrollees and Degree Holders						
		2-year			4-year	
($)	Enrollee	Degree Holder		Enrollee	Degree Holder	
SAVE – Baseline	1,103	1,660		1,598	2,471	
RAP – Baseline	383	805		840	1,325	
Panel C: Consumption and Work Hours During College Years						
		Annual Consumption ($)			Weekly Work Hours in College	
SAVE – Baseline		1,517			-0.21	
RAP – Baseline		775			-0.07	

Notes: This table shows changes in outcomes from the baseline to SAVE/RAP, as described in the text. Panel A reports changes in college enrollment and degree attainment outcomes. “Enrollment” is the proportion of the full sample who enroll in a 2-year or 4-year college. “Degree” is the proportion of the full sample who hold a 2-year or 4-year college degree. “GradRate” is the ratio of “Degree” to “Enrollment”. Panel B reports changes in the average student loan amount among enrollees and degree holders. Panel C reports changes in the average in-college annual consumption and average weekly work hours while enrolled. All dollar values are reported in 2012 USD.

Table E9: Earnings, Assets, and Human Capital by Repayment Plan (Full Sample; NBL)

Panel A: Cumulative Earnings, Assets, and Human Capital			
($)	Earnings (post edu. to Age 44)	Assets (Age 45)	HK (Age 45)
SAVE - Baseline	9,744	1,130	951
RAP - Baseline	4,995	110	539

Panel B: HK at Market Entry, Hours, and On-the-Job HK Investment			
	HK at Market Entry ($)	Avg. Weekly Work Hrs	Avg. OTJ HK Inv. ($)
SAVE - Baseline	575	-0.07	318
RAP - Baseline	208	-0.03	342

Notes: Each row reports changes in the average outcomes under SAVE/RAP versus the baseline. Earnings refer to the discounted sum of earnings from labor market entry up to Age 44. Human capital (HK) is expressed in dollar terms and reflects the earnings a worker would obtain from full-time employment when allocating all time to production rather than investment. Labor market entry refers to the first year of work after completing schooling for college attendees and at age 18 for high school graduates. Average work hours represent weekly hours averaged over the labor market period; average OTJ investment is the annual average value of foregone earnings due to time spent on skill accumulation. All values are reported in 2012 USD.

Panel B highlights the mechanisms behind our findings. First, the human capital effect at labor market entry increases under SAVE and RAP, relative to the baseline, reflecting greater pre-market HK accumulation. Second, while IDR plans could in theory reduce work incentives, the effects on average weekly work hours are negligible (-0.07 under SAVE and -0.03 under RAP). Third, by reducing repayment burdens when income is low, IDR plans, particularly SAVE, enable greater post-schooling investment in human capital, as reflected in higher average on-the-job HK investment per year.

Individual Welfare

To evaluate individual welfare, we compute the discounted consumption-equivalent variation (CEV) each person would require under the baseline to be as well off as under a given IDR policy. Table E10 summarizes the cross-sectional distribution of welfare changes relative to the baseline. Similar to the findings in the main text, both SAVE and RAP increase individual welfare.

Table E10: Changes in Individual Welfare (CEV; NBL)

($)	SAVE vs. Baseline	RAP vs. Baseline
25th Percentile	39	37
Median	2,640	1,204
75th Percentile	8,830	6,575
Mean	3,739	3,869

Notes: This table reports the distribution of changes in individual welfare under alternative repayment plans, relative to the baseline, at selected percentiles (25th, median, 75th) and the mean. Welfare changes are measured as the discounted sum of consumption equivalent variation (CEV). All values are expressed in 2012 USD.

Government Revenue and Social Welfare

Table E11 presents changes in discounted government revenue under alternative repayment plans relative to the baseline. Column 1 reports changes in tax revenue from lifetime earnings (up to age 62), Column 2 reports changes in net loan revenue, and Column 3 combines the two.

Table E11: Government Revenue and Social Welfare Changes (Full Sample; NBL)

($)	ΔTax Rev.	ΔLoan Rev.	ΔGov. Rev.	CEV	ΔWelfare
SAVE – Baseline	3,629	-356	3,273	3,739	7,011
RAP– Baseline	2,051	69	2,120	3,869	5,989

Notes: Each row shows changes in government revenue and individual welfare under alternative repayment plans, relative to the baseline; all numbers are discounted to the present value at $t = 1$. ΔTax Revenue is the change in total lifetime tax collection. ΔLoan Revenue is the discounted present value of loan repayment minus the amount lent (negative values indicate a loss). ΔGov. Revenue combines changes in tax and loan revenue. CEV refers to the consumption-equivalent variation, and ΔWelfare is the sum of ΔGov. Revenue and CEV. All values are expressed in 2012 USD.

To compute post-age-44 tax revenue, we assume that all individuals work full-time until age 60 and part-time until age 62, investing in human capital until age 55 just enough to offset depreciation. Under these assumptions, SAVE generates an average tax revenue gain of $3,629 per person but a loan revenue loss of $356, resulting in a net government revenue gain of $3,273. RAP produces a smaller increase in tax revenue

($2,051) but a small loan profit, yielding a net revenue gain of $2,120. Combining changes in government revenue with individual CEV provides a measure of social welfare (Column 5). SAVE raises social welfare by $7,011 per person, while RAP raises it by $5,989.

Overall, these results suggest that SAVE is fiscally unsustainable for a private lender, who would incur losses, whereas RAP would generate a small positive return. However, once income taxes are accounted for, both IDR schemes become fiscally viable and yield a "win-win" outcome: they facilitate human capital investment, improve individual welfare, and increase government revenue. The welfare and fiscal gains are larger under SAVE than under RAP.

F Simulating the Impact of High Tuition (PBL)

We apply our estimated PBL model to examine how higher tuition costs, similar to the costs faced by later cohorts such as the NLSY97 cohorts (born in 1980-1984), would affect educational attainment and post-education decisions.

To simulate the higher tuition environment, we adjust net tuition costs based on differences in tuition-to-income ratios between NLSY79 and NLSY97. To do so, we use net tuition and fee data from the College Board's Trends in College Pricing (2006),[1] as well as the information on the growth in real household income overtime from the Census.[2] Holding all other initial conditions (including parental income levels) fixed, these data allow us to calculate the counterfactual net tuition-to-income ratios (hence the net tuition costs) for two- and four-year colleges faced by each parental income group in our sample had they graduated from high school in 2002.[3] In particular, the original (low) net tuition and the counterfactual (high) net tuition for each parental income group by college type are given by Table F1.

Table F1: Net Tuition (2012 USD)

	Original (Low Tuition)		Counterfactual (High Tuition)	
Parental Income Tercile	2-year	4-year	2-year	4-year
1 (lowest)	55	2,352	747	5,022
2 (middle)	470	3,475	1,303	7,373
3 (highest)	990	4,007	1,737	10,297

Notes: The counterfactual (high tuition) values are constructed by scaling net tuition using tuition–to–income ratios from the College Board's *Trends in College Pricing* (2006) and observed income growth from the Census. All amounts are in 2012 USD.

[1]Trends in College Pricing (2006) (`https://research.collegeboard.org/trends`) reports net tuition by parental income quartile. Since our model is based on terciles, we re-map quartiles into terciles using weighted averages. The report also distinguishes among 4-year public, private nonprofit, and for-profit institutions; we aggregate these into a single 4-year category using enrollment-share weighted averages.

[2]U.S. Census Bureau, Real Median Household Income in the United States [MEHOINUSA672N], FRED, Federal Reserve Bank of St. Louis; `https://fred.stlouisfed.org/series/MEHOINUSA672N`.

[3]The net tuition-to-income ratio for 2-year colleges for the low/middle/high parental income group rises from 0.21/0.70/0.90% to 2.40/1.73/1.58%. For 4-year colleges, the corresponding increase is from 9.00/5.50/3.70% to 16.16/9.76/7.89%.

F.1 Impacts of Tuition Increase under the Standard Repayment Plan

Table F2 reports differences in outcomes between the counterfactual high-tuition environment and the baseline low-tuition environment, both under the standard repayment plan regime. When tuition increases, Panel A shows a substantial reallocation away from four-year colleges: Four-year enrollment falls by 8.8 percentage points (ppts) and degree attainment by 2.17 ppts. Although two-year college enrollment rises by 1.75 ppts and degree completion increases by 0.28 ppts, these increases are minor relative to the corresponding decreases in the four-year college sector, leading to overall lower college enrollment and attainment. These findings are consistent with prior evidence that higher tuition reduces college participation (Leslie and Brinkman, 1988; Cameron and Heckman, 2001).

Table F2: Education-Related and Economic Outcomes (High vs. Low Tuition)

Panel A: College Enrollment and Attainment						
	2-year			4-year		
(ppts)	Enroll	Degree	GradRate	Enroll	Degree	GradRate
High – Low	1.75	0.28	-0.78	-8.80	-2.17	7.45
Panel B: College Loan among Enrollees and Degree Holders						
	2-year			4-year		
($)	Enroll	Degree		Enroll	Degree	
High – Low	89	105		398	-5	
Panel C: Consumption and Work Hours During College Years						
	Annual Consumption ($)			Work Hours (per week)		
High – Low	-3,464			0.59		
Panel D: Cumulative Earnings, Assets, and Human Capital						
($)	Discounted Earnings (to Age 44)			Assets (Age 45)		Human Capital (Age 45)
High – Low	-19,341			-3,594		-3,142
Panel E: Human Capital at Entry, Hours, and HK Investment on the Job						
	Human Capital ($ Entry)			Avg. Work Hours		Avg. HK Investment ($)
High – Low	-1,794			0.25		-1,029

Notes: This table reports the differences in education-related and economic outcomes between high- and low-tuition environments under the baseline repayment plan. Panel A shows differences in college enrollment, degree attainment, and graduation rates (in percentage points). "Enroll" is the proportion of the full sample who enroll in a 2-year or 4-year college, "Degree" is the proportion who attain a degree, and "GradRate" is the ratio of degrees to enrollment. Panel B shows the difference in average student loan amounts (in dollars) among enrollees and degree holders. Panel C reports the difference in average annual consumption (in dollars) during college and average weekly work hours while enrolled. Panel D reports differences in discounted lifetime earnings up to age 44, as well as assets and human capital at age 45 (all in dollars). Panel E reports differences in human capital at college entry, average weekly work hours, and average annual human capital investment on the job (in dollars). All entries are expressed as the difference between high-tuition and low-tuition environments (High – Low).

Panel B of Table F2 shows that higher tuition increases student loan balances among enrollees: by $398 for four-year students and by $89–$105 for two-year students. Panel C shows that when placed in the high-tuition environment, college students reduce annual consumption by $3,464 and increase weekly work hours by 0.6. Panel D shows that discounted lifetime earnings (up to Age 44) decline by $19,341 and that at Age 45, assets fall by $3,594 and human capital by $3,142. Panel E shows that the increase in tuition lowers HK upon market entry and on-the-job HK investment, while increasing post-education work hours.

In sum, higher tuition (i) shifts enrollment away from four-year colleges and reduces overall educational attainment, (ii) increases borrowing among college enrollees, and (iii) reduces earnings, wealth, and human capital while increasing work hours. That is, the increase in tuition suppresses both education and on-the-job human capital investment and imposes lasting economic consequences.

Remark 1 *Notice that the simulation does not capture the observed increase in college enrollment that coincided with higher tuition and greater student debt. This arises because this exercise isolates the effects of tuition increases, while the observed data patterns are also driven by changes in the labor market returns to college education.*

F.2 The Role of IDRs in the High Tuition Environment

Now we investigate the role of income-driven repayment (IDR) plans–SAVE and RAP described in the main text–in the high tuition environment. We present changes in various outcomes when the baseline repayment regime switches to SAVE/RAP.

Table F3 presents the impact of SAVE on various outcomes in the low-tuition environment (the first row in each panel) and in the high-tuition environment (the second row in each panel). Table F4 is the RAP counterpart of Table F3. Both tables show that IDRs' impacts tend to be larger when tuition is higher.

For example, Panel A of Table F3 shows that SAVE has a larger impact on educational achievement when tuition is high: The fraction of four-year college degree holders increases by 1.4 (0.95) ppts and that of any college degree holders increases by 2.1 (1.8) ppts in the high-tuition (low-tuition) case.[4] Panel B shows that SAVE increases in-college consumption and reduces in-college work hours more when tuition is high. Panel C shows that SAVE leads to higher earnings and assets, and this effect is larger when tuition is high: The discounted lifetime earnings increase by $4,497 and assets at age 45 by $1,383 in the high-tuition case, while the corresponding numbers in the low-tuition case are $3,669 and $701, respectively.

References

Cameron, S. V. and Heckman, J. J. (2001). The Dynamics of Educational Attainment for Black, Hispanic, and White Males. *Journal of Political Economy*, 109(3):455–499.

Leslie, L. and Brinkman, P. (1988). *The Economic Value of Higher Education*. American Council on Education/Macmillan Series on Higher Education. American Council on Education.

[4]The fraction of any degree holders refers to the sum of the second and the fourth columns, e.g., $2.1 = 0.69 + 1.4$.

Table F3: Differences in Outcomes under SAVE compared to the baseline (Low vs. High Tuition)

Panel A: College Enrollment and Attainment

	2-year			4-year		
(ppts)	Enroll	Degree	GradRate	Enroll	Degree	GradRate
Low Tuition	0.70	0.84	3.00	0.69	0.95	1.33
High Tuition	0.32	0.69	2.63	1.17	1.40	2.40

Panel B: Consumption and Work Hours During College Years

	Annual Consumption ($)	Work Hours (per week)
Low Tuition	874	-0.68
High Tuition	973	-0.73

Panel C: Cumulative Earnings, Assets, and Human Capital

($)	Discounted Earnings (to Age 44)	Assets (Age 45)
Low Tuition	3,669	701
High Tuition	4,497	1,383

Notes: Each panel reports the effects of SAVE relative to the baseline under two tuition regimes. Panels A–B cover enrollment, attainment, and in-college outcomes. Panel C shows lifetime earnings and assets. All outcomes are differences from the baseline, reported in 2012 USD.

Table F4: Differences in Outcomes under RAP compared to the baseline (Low vs. High Tuition)

Panel A: College Enrollment and Attainment

	2-year			4-year		
(ppts)	Enroll	Degree	GradRate	Enroll	Degree	GradRate
Low Tuition	0.06	0.57	2.62	0.36	0.62	1.01
High Tuition	-0.06	0.46	2.07	0.50	0.80	1.45

Panel B: Consumption and Work Hours During College Years

	Annual Consumption ($)	Work Hours (per week)
Low Tuition	609	-0.60
High Tuition	681	-0.60

Panel C: Cumulative Earnings, Assets, and Human Capital

($)	Discounted Earnings (to Age 44)	Assets (Age 45)
Low Tuition	2,317	128
High Tuition	2,595	480

Notes: Each panel reports the effects of RAP relative to the baseline under two tuition regimes. Panels A–B cover enrollment, attainment, and in-college outcomes. Panel C shows lifetime earnings and assets. All outcomes are differences from the baseline, reported in 2012 USD.