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The Federal Student Loan Program: Quantitative Implications for College Enrollment and Default Rates

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Abstract

I quantify the effects of alternative student loan policies on college enrollment, borrowing behavior, and default rates in a heterogeneous model of life-cycle earnings and human capital accumulation. I find that the combination of learning ability and initial stock of human capital drives the decision to enroll in college, while parental wealth has minimal effects on enrollment. Repayment flexibility increases enrollment significantly, whereas relaxation of eligibility requirements has little effect on enrollment or default rates. The former policy benefits low-income households, while the latter has negligible effects on these households.
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1 Introduction

The Federal Student Loan Program (FSLP) has become one of the most important sources of college financing in the U.S. More than 10 million loans were granted under the program in 2004, for a total of \$52 billion (College Board (2003)).[1] While the default rate on student loans declined substantially from 22.4% in 1990 to 5.4% in 2003 (a 2-year basis, cohort-default rate), it remains a significant concern to policymakers. The total amount of outstanding debt reached \$25 billion in 2001 (Department of Education (2001)). This paper analyzes the interaction of educational opportunities, college financing and repayment incentives under the current FSLP.

Policy makers insist that subsidies are needed to educate children from low-income families. At the core of this argument stands a strong positive relationship between family income and college enrollment. However, policymakers are also worried about student loan default rates. As a result, legislators have introduced a series of policy reforms that has made the student loan program more generous and at the same time attempted to reduce default rates. The design of the current program is such that college loans are based on financial need and are subsidized by the government. Borrowers enter repayment six months after graduation at a fluctuating interest rate.

In the last 20 years there have been several significant policy changes. An important policy reform that occurred in 1986 was a consolidation program with flexible repayment (Higher Education Amendment (HEA)). The reform allowed borrowers to switch to an income-contingent plan or lock-in interest rates at any time during the repayment phase of the loan. This reform helped students hedge against interest rate risk and lower their payments, inducing higher incentives to repay. A second relevant change in 1992 relaxed eligibility requirements (HEA in 1992) and redefined the expected family contribution, making it easier for students from high-income households to enter the program. The result was a significant increase in borrowing for higher education along with a change in the composition of borrowers: 44% of degree recipients in 1999-2000 from high-income families borrowed for college in 1999-2000 compared to only 8% in 1992-1993 (American Council of Education (2001)). Finally, changes in the bankruptcy rules have gradually made student loans nondischargeable under Chapter 13, one of the reorganization chapters in the Bankruptcy Code.[2] The change from liquidation to reorganization has deterred students from declaring bankruptcy, given the more severe consequences of default. As a result, the default rate has declined substantially since 1990, as presented in Figure A-1.

A couple of questions arise immediately: Which policy was more effective in reducing default rates? What are the implications for college enrollment? The policy changes under the program

[1] In 2001 unsecured consumer debt amounted to \$692 billion (Chatterjee et al. (2007)). Total student aid from the government and other sources amounted to \$129 billion in 2004-2005.

[2] Dischargeability was initially restricted in 1990 to a 7-year first-payment basis or undue-hardship basis, the first provision being eliminated from the Bankruptcy Code by the HEA in 1998.

clearly open new opportunities, but for whom? This paper provides a framework that can be used to analyze the implications of various education policies across different characteristics of high school graduates. I investigate student loan policies by embedding them in a heterogeneous economic model of life-cycle learning and skill accumulation. Specifically, I quantify the effects of the introduction of the consolidation program with flexible repayment and the relaxation of eligibility requirements.[3] I examine the relevance of parental wealth versus individual characteristics for college enrollment under the current design of the FSLP.

To address the proposed issues, I develop a life-cycle economy that generalizes the Ben-Porath (1967) model of earnings and human capital. I build on earlier work by Huggett et al. (2006) and extend it in several directions. First, I allow for heterogeneity in learning ability, initial human capital stock, and parental contribution to college. As in Ben-Porath, learning ability does not change over time, whereas human capital stock can be accumulated over the life-cycle. In addition, my model allows for borrowing to finance college. Central to my model is the decision of the high school graduate to invest in his college education and to borrow against his own future income. Moreover, the interest rate on college loans is uncertain, making college enrollment a risky choice. Finally, the agent can self-insure against these shocks only by accumulating assets in the risk-free market. The government intervenes to help the college graduate insure against interest-rate risk through flexible repayment schemes on educational loans. To conduct the proposed policy experiments, I calibrate the model to match key properties of the life-cycle earnings distribution for high school graduates from the CPS data for 1969-2002 in the spirit of Huggett et al. (2006).

My results imply that the combination of ability and initial human capital stock determines the decision to enroll in college, while parental wealth has minimal effects on college enrollment.[4] However, I find that a change in policy that allows students to lock-in interest rates or to switch repayment plans leads to higher college enrollment rates and a substantial decline in default rates, causing substantial redistributional effects across groups of high school graduates. On the other hand, relaxed eligibility requirements have little effect on enrollment or default rate with few minimal redistributional effects. In particular, more flexibility in repayment delivers gains for borrowers who are low-income, have high-ability, and have average levels of human capital. I conclude that subsidizing repayment rather than relaxing constraints by the time of college enrollment could make college investment more attractive for people from low-income families. For them, the risk of financing college seems to be substantial (Chatterjee and Ionescu (2008)), and flexibility in repayment helps reduce this risk.

[3] The change in bankruptcy rules is equally significant. They are, however, of separate interest and represent the focus of a different study.

[4] This is consistent with recent research by Carneiro and Heckman (2002) and Heckman (1999).

1.1 Contribution to the Literature

Government policies related to higher education and their implications for human capital investment have been extensively researched, with significant contributions by Avery and Hoxby (2002), Becker (1993), Caucutt and Kumar (2003), Heckman and Carneiro (2003), Heckman et al. (1998b), and Keane and Wolpin (2001). The literature has generally ignored, however, the analysis of the effects of recent changes in student loan policy on college enrollment and default incentives. Two relevant papers to the current study are Ionescu (2008) and Lochner and Monge (2008). Ionescu (2008) explains repayment patterns and default incentives under the FSLP across different groups of college graduates, focusing on incentives created by two main sources of risk: interest rate uncertainty and income uncertainty. In contrast, the current paper focuses on college enrollment and debt chosen by high school graduates along with their repayment incentives and analyzes the implications of various education policies across different characteristics of high school graduates. The policy experiment is also different: Ionescu (2008) analyzes the impact of a 2006 reform that eliminates the possibility to lock-in interest rates for student loans, whereas the current paper quantifies the effects of alternative loan policies introduced in the early 1990s. Lochner and Monge (2008) make an important contribution to the literature by studying the interaction between borrowing constraints, default, and investment in human capital in an environment based on the U.S. Guaranteed Student Loan Program (GSL) where constraints arise endogenously from limited repayment incentives. My study differs from theirs in several important ways. First, I incorporate the available repayment schedules, including the opportunity to lock-in interest rates and to switch to an income-contingent plan. Second, I focus on the FSLP, whereas they focus on the GSL program (the former FSLP) with a different set of rules upon default. Consequently, default penalties are modeled differently. Third, I model heterogeneity in ability, stock of human capital, and wealth and estimate their distributions by matching earnings statistics of high school graduates in the U.S. data. In contrast, Lochner and Monge (2008) model heterogeneity in ability and wealth, measure ability by AFQT scores and analyze investment behavior for the estimated ability types and a range of potential wealth levels. Fourth, I propose an analysis of alternative student loan policies, whereas their research focuses on the severity of punishments upon default and government subsidies.

To my knowledge, this is the first paper to investigate the implications of student loan policies on college enrollment, borrowing, and default incentives in a framework that accounts for the risk of financial investment in college and the role of government to provide insurance against this risk. More important, it takes a deeper approach by allowing for heterogeneity in initial human capital, learning ability, and wealth. Individuals who choose to invest in college education may have other unobserved characteristics that differ from those who choose less education. This paper provides a framework that accommodates this issue.

The choice of my model is motivated by empirical and theoretical work on how individual characteristics and family background influence human capital accumulation over the life-cycle. Starting in the early 1970s it has been widely accepted that the decision to attend college is influenced by expected gains in lifetime earnings, which in turn are determined by unobservable characteristics.[5] Becker (1964) showed how the complementarity between ability and human capital investments could be explored in order to explain many features of earnings distributions and earnings dynamics that models of innate cognitive ability could not. Ben-Porath (1967) provides a rigorous formulation of earnings that combines a theory of earnings with a theory of human capital investment and emphasizes that innate ability is an input into the production of human capital and the stock of human capital increases the productivity of additional investment in human capital.[6] Additionally, the Ben-Porath model recognizes the distinction between potential and actual earnings, providing the theory missing in Mincer's analysis. It links schooling and on-the-job training decisions through human capital accumulation and ties those decisions to the earnings function. The Ben-Porath model provides the framework for testing the relationship between earnings and schooling. The model, however, assumes income-maximizing agents who face no savings or borrowing decisions. It also suggests that different amounts of human capital represent different amounts of the same skills and predicts that earnings do not jump after schooling, but gradually increase from 0, which is not consistent with the data.

Heckman et al. (1998a) extend the Ben-Porath framework, decouple the schooling decision from on-the-job training, and present a model that produces a substantial earnings jump upon completion of schooling. This generates the rising wage inequality measured by the college/high school wage differential. In Heckman et al. (1998a), however, earnings of one agent in the model best match earnings data for individuals sorted by a measure of ability (AFQT quartiles) and by whether or not they went to college. Consequently, the contribution of schooling to subsequent learning and earning is embodied in the schooling-specific skills as well as initial endowments. In contrast, Huggett et al. (2006) demonstrate that the U.S. distribution dynamics can be well matched by the Ben-Porath model from the right joint distribution of ability and human capital, and emphasize that differences in learning ability are essential, but differences in human capital early in the life-cycle are also important.[7] As a result, the shape of the distribution of initial conditions is central to quantifying changes in schooling decisions driven by education policy.

[5] Willis and Rosen (1979) find that the total variance of earnings among people of the same sex, race, education, and market experience is large and more than two-thirds of it is attributable to unobserved components. Mincer (1974) provides the important insight that measured earnings are less than potential earnings so that earnings functions are not just pricing functions for observed characteristics.

[6] More recently, Heckman and Carneiro (2003) summarize a body of evidence that suggests that this complementarity is empirically important.

[7] According to Huggett et al. (2006), differences in learning ability account for most of the variance in the present value of earnings (as of age 20). Differences in ability account for more than 60 % of the total variance. The residual variance is due to human capital differences at fixed ability levels.

Thus, I allow for heterogeneity in ability and human capital heterogeneity, and I pin down their initial distribution by matching key properties of life-cycle earnings of high school graduates in the U.S. data.

With respect to the third dimension of heterogeneity in my model, initial wealth, there is a large literature, initiated by Becker and Tomes (1979), that emphasizes the relevance of credit constraints and family income on schooling decisions. While I model parental contribution for college as part of the initial conditions, agents are not borrowing constrained in my setup, a feature often present in the literature on schooling and human capital accumulation. In my model, if agents choose to go to college, they can borrow the necessary funds. This is motivated by two main observations. First, since the HEA in 1980, the FSLP is based on financial need and thus makes college funds available for people from low and middle income families. Expected family contribution is key to borrowing decisions under the program. Second, recent empirical research documents that long-run family factors correlated with income affect schooling, but short-run credit constraints are not empirically important.[8] Better family resources in a child's formative years are associated with higher quality of education and better environments that foster cognitive and noncognitive skills, which in turn affect educational attainment and performance. In a structural model of schooling and work that incorporates borrowing and parental transfers, Keane and Wolpin (2001) estimate tight borrowing limits. They found, however, that borrowing constraints have little effect on educational attainment.

In conclusion, the insights provided by recent research change the way we interpret the evidence and design education policy. A rich framework that allows for both observable and unobservable characteristics together with human capital accumulation tied to life-cycle earnings should be used. More important, the distribution of initial characteristics should be estimated such that the model matches the earnings profile for high school graduates, a key component for the college enrollment decision. Finally, in addition to family income, a model of college choice should account for additional sources of funds available to high school graduates together with the relevant institutional details.

The rest of the paper is organized as follows: Section 2 presents the model; Section 3 describes the calibration procedure; the results are given in Section 4; and Section 5 concludes. Data details and the computational algorithm are provided in the appendix.

[8]See Cameron and Heckman (1998), Cameron and Heckman (2001), Cameron and Taber (2004), and Carneiro and Heckman (2002).

2 Model

The environment is a life-cycle economy with heterogeneous agents that differ in their learning ability (a), human capital stock (h), and initial assets (x), which include parental contribution to college. Time is discrete and indexed by $j = 1, ..., J$ where $j = 1$ represents the first year after high school graduation. I model the decision of a high school graduate to invest in his college education by maximizing the present value of utility over the life-cycle:

$$\max \sum_{j=1}^{J} \beta^{j-1} u(c_j), \tag{1}$$

where $u(.)$ is strictly concave and increasing, and β is the discount factor. The per period utility function is CRRA, $u(c_j) = \frac{{c_j}^{1-\sigma}}{1-\sigma}$, with σ as the coefficient of risk aversion.

My model is a generalization of the human capital model developed by Ben-Porath (1967) and updated by Huggett et.al. (2006), which I extend in several ways. I allow for human capital accumulation in college. I assume that the technology for human capital accumulation is the same during and after college and that human capital is not productive until college graduation. There are three sources of heterogeneity: immutable learning ability, initial stock of human capital and initial assets. College costs can be financed by parental contribution and student loans. Financing higher education is risky: the interest rate on loans is uncertain.

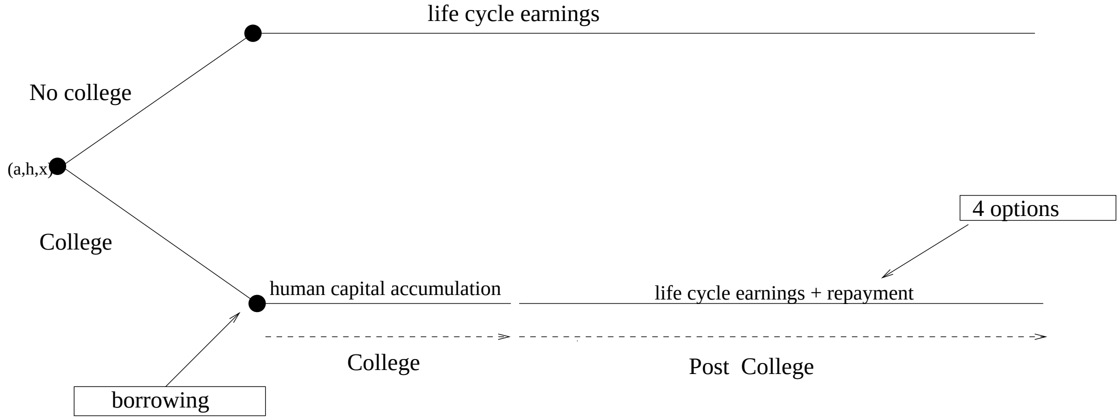
On the college path as well as on the no-college path, agents optimally allocate time between market work and human capital accumulation. Human capital stock refers to "earning ability" and can be accumulated over the life-cycle, while learning ability is fixed at birth and does not change over time. Agents may save at the riskless interest rate. Additionally, agents on the college path optimally choose the loan amount and the repayment option for college loans. When deciding to go to college, agents might not have sufficient funds and need to borrow to continue their education. They start repaying their loans once they graduate from college at a fluctuating interest rate. Hence higher levels of student loans will make college financing a riskier choice. A description of the timing in the model is provided in Figure 1.

The optimal life-cycle problem is solved in two stages. First, for each schooling choice, I solve for the optimal path of consumption, time allocation, and human capital investment. In the case of college graduates, I also solve for optimal borrowing and repayment decision rules. Individuals then select between college versus no-college to maximize lifetime utility.

2.1 Agent's Problem: No-College Path

Agents who choose not to go to college maximize the present value of utility over their lifetime by dividing available time between market work and human capital accumulation; they save in

Figure 1: Timing of Decisions



the risk-free asset market. Their problem is identical to the one described in Ben-Porath (1967) except for the saving option and risk aversion. The problem is given by:

$$\begin{aligned} \max_{l_j,h_j,x_j} \quad & \left[\sum_{j=1}^{J} \frac{c_j^{1-\sigma}}{1-\sigma}\beta^{j-1}\right] \\ s.t. \quad & c_j \leq w_j h_j(1-l_j) + (1+r_f)x_j - x_{j+1} \text{ for j=1,2...J} \\ & l_j \in [0,1],\ h_{j+1} = h_j(1-\delta_{nc}) + f(h_j, l_j, a),\ x_j \geq 0. \end{aligned} \tag{2}$$

Agents derive utility from consumption each period; earnings are given by the product of the rental rate of human capital, w_j, the agent's human capital, h_j, and the time spent in market work, $(1-l_j)$. Agents may save, x_{j+1}, at the riskless interest rate, r_f. Their initial assets, x_1, include the parental contribution for college education. The depreciation rate of human capital is δ_{nc}. Human capital production, $f(a, h_j, l_j)$, depends on the agent's learning ability, a, human capital, h_j, and the fraction of available time put into human capital production, l_j. Following Ben-Porath (1967), this is given by $f(h,l,a) = a(hl)^\alpha$ with $\alpha \in (0,1)$. The rental rate of human capital evolves over time according to $w_j = (1+g_{nc})^{j-1}$ with the growth rate, g_{nc}.

I formulate the problem in a dynamic programming framework. The value function $V(a,h,x,j)$, gives the maximum present value of utility at age j from states h and x when learning ability is a. In the last period of life (J) the agent consumes his savings. The value function after the last period of life is set to 0, (i.e., $V(a,h,x,J+1) = 0$).

$$\begin{aligned} V(a,h,x,j) \quad = \quad & \max_{l,h',x'} \left[\frac{(wh(1-l) + (1+r_f)x - x')^{1-\sigma}}{1-\sigma} + \beta EV(a,h',x',j+1)\right] \\ & s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^\alpha,\ x \geq 0. \end{aligned} \tag{3}$$

Solutions to this problem are given by the optimal decision rules: $l_j^*(a,h,x)$, $h_j^*(a,h,x)$, and $x_j^*(a,h,x)$, which describe the optimal choice of the fraction of time spent in human capital production, human capital, and assets carried to the next period as a function of age j, human capital, h, ability, a, and assets, x. The value function, $V_{NC}(a,h,x) = V(a,h,x,1)$, gives the maximum present value of utility if the agent chooses not to go to college when learning ability is a, human capital is h, and initial assets are x.

2.2 Agent's Problem: College Path

As in the previous case, agents who pursue college maximize the present value of utility over their lifetime by dividing available time after graduation between market work and human capital accumulation. They also save using the risk-free asset. Additionally, they optimally choose the loan amount for college education and the repayment option for their college loan in order to maximize the present value of utility. The problem is given below by:

$$\max_{l_j,h_j,x_j,p_j,d} \left[E \sum_{j=1}^{J} \beta^{j-1} \frac{c_j^{1-\sigma}}{1-\sigma} \right] \tag{4}$$
$$\begin{aligned} s.t. \quad & c_j \leq (1-l_j) + x_j(1+r_f) + t(a) + d - \hat{d} - x_{j+1} \text{ for j=1,...,4} \\ & c_j \leq w_j h_j (1-l_j) - p_j(d_j) + x_j(1+r_f) - x_{j+1} \text{ for j=5,...,J} \\ & l_j \in [0,1],\ h_{j+1} = h_j(1-\delta_c) + f(h_j, l_j, a),\ x_j \geq 0 \\ & d \in D = [0, \overline{d}(x)],\ d_{j+1} = (d_j - p_j)(1+r_j),\ p_j \in P. \end{aligned}$$

For college period $j = 1, .., 4$, the growth rate, g_c, is 0. Thus, the rental rate of human capital is 1 during college. Human capital is not productive until graduation. This assumption is consistent with evidence that the majority of full-time college students do not work while in school.[9] In addition, the jobs college students have do not necessarily value students' human capital stocks, nor do they contribute to human capital accumulation. The set of skills involved in these jobs is different from the one students acquire in college and use after graduation.[10] Finally, people who choose to work while in school most likely drop out of college, as numerous studies attest.[11] While working during college seems to be an important factor for human capital accumulation for college dropouts, since I do not model college completion, I also abstract from modeling part-time work during college. This formulation is in line with research by Keane and Wolpin (1997). I discuss, however, the implications of relaxing this assumption at the end of this section.

[9] According to Manski (1983), 25 % of full-time college students work part-time and 3.25 % work full-time. Similar figures are provides by NCES surveys together with trends on college attendance, employment, and hours worked per week (Planty and Kemp (2008)).

[10] Economists frequently recognize that the skills used by less educated and highly educated workers are not perfectly substitutable (Autor et al. (2003) and Peri and Sparber (2007)).

[11] Relevant studies include GAO (2003a) and Berkner et al. (2002), which is based on data from 1995-1996 Beginning Postsecondary Students study (BPS), Braxton et al. (2003), Cabrera et al. (1993), Stinebrickner and Stinebrickner (2007), and Tinto (1993).

Agents are allowed to borrow up to $\overline{d}(x)$, the full college cost minus the expected family contribution that depends on initial assets, x.[12] Agents use the loan amount and initial assets to pay for college expenses while in college. This feature is very important, since it prevents college graduates from having an advantage over the no-college group in having access to government borrowing and using it for consumption over the life-cycle. They pay direct college expenses, $\hat{d}$, and receive a transfer, $t(a)$, each period while in college.[13] Agents derive utility from consuming each period. After they graduate from college, their earnings are given by the product of the rental rate of human capital, w_j, the agent's human capital, h_j, and the time spent in market work, $(1-l_j)$. Their current savings are x_{j+1}, and payment delivered each period is $p_j(d_j) \in P$.[14] The interest rate on loans, r_j, is stochastic and follows a two-state Markov process. As before, the stock of human capital increases when human capital production offsets the depreciation of current human capital given by rate, δ_c. Once again, human capital production, $f(h_j, l_j, a)$, is given by $f(h, l, a) = a(hl)^\alpha$ with $\alpha \in (0, 1)$. I assume that the technology for human capital accumulation is the same during schooling ($j = 1, ..., 4$) and training periods ($j = 5, ..., J$), given by $h_{j+1} = h_j(1-\delta_c) + a(h_j l_j)^\alpha$. The rental rate equals $w_j = (1+g_c)^{(j-1)}$ with the growth rate, g_c.

The college path problem is solved in several steps. As before, I formulate it in a dynamic programming framework. The value function after the last period of life is set to 0, (i.e. $V(a, h, x, d, r, J+1) = 0$). The problem is solved backward, starting with the post-college period, ($j = 5, .., J$), for which the Bellman equation is given by

$$\begin{aligned} V(a,h,x,d,r,j) &= \max_{l,h',x',p,d'} \left[\frac{(w_j h(1-l) + (1+r_f)x - x' - p(d))^{1-\sigma}}{1-\sigma} + \beta E V(a,h',x',d',r',j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^\alpha,\ x \geq 0 \\ & \quad d' = (d-p)(1+r),\ p \in P. \end{aligned} \tag{5}$$

I use $V_5(a, h, x, d, r)$ as the terminal node for the college period and solve for the optimal rules for $j = 2, ..., 4$. The Bellman equation is

$$\begin{aligned} V(a,h,x,d,j) &= \max_{l,h',x'} \left[\frac{((1+r_f)x + 1 - l + t(a) + d - \hat{d} - x')^{1-\sigma}}{1-\sigma} + \beta V(a,h',x',d,j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^\alpha. \end{aligned} \tag{6}$$

[12] In practice, financial need is determined by comparing the cost of college to the student's ability to pay for it, which is measured by the expected family contribution (EFC). The EFC is based on family income and assets (including the student's own financial resources), with adjustments for family size and the number in the family concurrently enrolled in college. For details see Berkner and Bobbitt (2000).

[13] This depends on the agent's ability and is interpreted as a scholarship that higher ability agents may receive.

[14] Repayment in the model is governed by the rules of the FSLP. The rules are very complex and presented separately in Subsection 2.2.1.

Finally, I solve for the optimal rules for the first period of college which also includes the optimal loan amount for college education. The Bellman equation for the first year in college is

$$\begin{aligned} V(a,h,x,1) \quad &= \quad \max_{l,h',x',d} \left[\frac{((1+r_f)x + 1 - l + t(a) + d - \hat{d} - x')^{1-\sigma}}{1-\sigma} + \beta V(a,h',x',d,2) \right] \\ & s.t. l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & d \in D = [0, \overline{d}(x)]. \end{aligned} \tag{7}$$

Solutions to this problem are given by optimal decision rules: $l^*_j(a,h,x,r)$, the fraction of time spent in human capital production, $h^*_j(a,h,x,r)$, human capital, and $x^*_j(a,h,x,r)$, assets carried to the next period as a function of age, j, human capital, h, ability, a, assets, x, and college debt, d, when the realized state is r. Additionally, for the post-college period, rules include $p^*_j(a,h,x,d)$, optimal repayment choice for $j \geq 5$, and $d^*(a,h,x)$, optimal borrowing for $j = 1$. The value function, $V_C(a,h,x) = V(a,h,x,1)$, gives the maximum present value of utility if the agent chooses to go to college from state h when learning ability is a and initial assets are x.

2.2.1 Repayment Options and Default

Student loans can be either subsidized (the U.S. Department of Education pays for the interest until the borrower starts repayment after graduation) or unsubsidized (the borrower is responsible for interest payments).[15] Under the FSLP, students start repaying their loans six months after graduation under a standard plan that lasts for 10 years. Payments fluctuate based on the 91-day Treasury bill interest rate. At any time after graduation, borrowers can choose, upon consolidation, to opt-out of this initial repayment plan, and they face a menu of repayment options, which include standard, graduated, income, and extended plans (for details see GAO (2003b)). Additionally, borrowers have the option to default on their education loans. However, default does not have the traditional meaning. It is merely a delay in repayment that comes with a cost on the part of the defaulter. If borrowers do not make any payments within 270 days, they are generally considered in default, unless they reach an agreement with the lender. In default, the line of credit is shut down and is transferred to government agencies that guarantee student loans. The guarantee agency holding the defaulter's loan reports the default status to the credit bureaus and designs a repayment plan that is immediately implemented together with a series of penalties on the defaulter. The defaulter enters repayment at a higher debt level, which may be up to 25 % of the principal. This higher debt recovers some of the collection costs of the defaulted loan. The defaulter also loses his right to consolidate after default. Part of the borrower's wage is garnished during the year default occurs, which may constitute up to 10 % of annual wages.

[15] This study focuses on loans subsidized by the government.

This punishment is stopped once the defaulter starts repayment. Finally, credit bureaus may be notified. Once the borrower starts repaying, bad credit reports are erased, however, and credit market participation is no longer restricted.

In the model, agents start repaying their loans under no consolidation status with fluctuating payments for T periods (T=10 years under the FSLP). As long as agents do not change this status, given the debt level, earnings, and interest rate they learn at the beginning of each period, they face four options: (1) keep paying at fluctuating payments, p_{nc} (no consolidation); (2) consolidate and lock-in interest rates without changing the standard plan; fixed payments are delivered until the loan is paid in full, p_{sc} (standard consolidation); (3) consolidate and switch to an income-contingent plan that assumes that payments are contingent on income realizations, p_{ic} (income consolidation); and (4) default, p_{def}. Agents cannot switch between the two consolidation plans (options 2 and 3). Consolidation can happen only once, and it does not involve any resource cost. Agents cannot partially consolidate. Once they consolidate, they extend the life of the loan to extra T periods under standard consolidation and up to T' periods under income consolidation ($T' = 25$ years under the FSLP).[16] Corresponding to the agents' three payment options, there are three types of payments, given by:

$$p_{nc_j} = \frac{d_j}{E\left[1 + \sum_{t=j+1}^{T} \frac{1}{\prod_{i=j+1}^{t}(1+r_i)}\right]} \text{ no consolidation;} \tag{8}$$

$$p_{sc_j} = \frac{d_j}{\sum_{t=0}^{T-1} \frac{1}{(1+r_k)^t}}, \text{ standard consolidation;} \tag{9}$$

$$p_{ic_j} = \lambda w_j h_j (1 - l_j), \text{ income consolidation,} \tag{10}$$

where d_j represents the debt level in period j and r_i the interest rate at period $i = j+1, ..., T$. Payments are computed to make the present value equal to the face value of debt d_j. For standard consolidation, T represents the number of payment periods after consolidation. The interest rate is fixed for the remainder of the loan, r_k, the rate at time of consolidation, k. For income consolidation, payments are given by a fraction λ of the agent's per period earnings. In case the loan is not fully paid after a number of periods, T', the remaining debt is discharged.[17] Payments under no consolidation are expressed in expected value terms, since there is interest rate uncertainty. Debt evolves according to the equation $d' = (d - p)(1 + r)$ where $p \in P = \{p_{nc}, p_{sc}, p_{ic}, p_{def}\}$, the payment made in the previous period.

There is no payment during the period in which default occurs, i.e., $p_{def_k} = 0$, but agents start repaying in the period $k + 1$ with fluctuating payments given by p_{nc} $\forall j > k$, where k represents

[16] I assume default does not occur post-consolidation. In practice, a negligible fraction of borrowers do so.

[17] Under the program, if a borrower under income consolidation or a defaulter cannot deliver full payments within 25 years, his remaining debt is forgiven.

the period in which default occurs. I do not allow for repeated default. While it is true that borrowers can default again, in practice, more severe punishments are imposed on borrowers who choose to repeatedly default, such as having the IRS withhold tax refunds and being excluded from credit markets. Defaulters do not end up in that stage for a long period of time.[18] As under income consolidation, in the case where default occurs, $p_j = 0$ after full payment is delivered or a maximum number of periods is reached ($T' = 25$ years under the FSLP), whichever comes first. As long as the agent does not choose to consolidate or default, the four options are available to him until full payment is delivered. Hence, for every period before T, the agent can be in one of the following states:

Case 1: Already consolidated under the standard plan

The agent locks-in an interest rate, which is determined at the time of consolidation and fixed for the life of the loan. This protects the borrower from future increases in interest rates, but it also prevents him from benefiting from future declines. The value function is given by V^{SC} below. If $d = 0$, the agent delivered full payment, so the function is valid as long as $d > 0$. There is no expectation, since the next period's rate is irrelevant after consolidation.

$$\begin{aligned} V^{SC}(a,h,x,d,r,j) &= \max_{l,h',x'} \left[\frac{(w_j h(1-l) + (1+r_f)x - x' - p_{sc}(d))^{1-\sigma}}{1-\sigma} + \beta V^{SC}(a,h',x',d',r,j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & \quad d' = (d - p_{sc})(1+r),\ d > 0, j = 1,2,...,T. \end{aligned} \tag{11}$$

Case 2: Already consolidated under the income plan

The value function is similar to the case above except that the payment represents a fraction, γ, of earnings. The function is valid as long as the agent has not finished repaying the loan, or the $T' = 25$ years limit is reached.

$$\begin{aligned} V^{IC}(a,h,x,d,r,j) &= \max_{l,h',x'} \left[\frac{(w_j h(1-l)(1-\gamma) + (1+r_f)x - x')^{1-\sigma}}{1-\sigma} + \beta E V^{IC}(a,h',x',d',r',j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & \quad d' = (d - \gamma w_j h(1-l))(1+r),\ d > 0, j = 1,2...,T'. \end{aligned} \tag{12}$$

Case 3: Already in default

Default in the model mimics the rules under the FSLP: agents do not make any payment during the period in which default occurs, and they start repaying their loan during the following

[18] Follow-up studies of defaulters reveal that two out of three defaulters reported making payments shortly after the official default first occurred (Volkwein et al. (1998)). In addition, Ionescu (2008) shows that if repeated default is allowed, the extra default is negligible (less than 1 %). Thus, given the complexity of the current setup, I choose not to model this option for tractability purposes.

period. The consequences of default mimic those in the data. Agents lose their rights to consolidate and need to repay a higher debt level.[19] In the period after default occurs, at $j = k$, the borrower enters repayment under the fluctuating interest rate for the debt level $d_{k+1} = d_k(1+\mu)$, i.e., $p_{def_{k+1}} \in \{p_{nc}\}$. In addition to the increase in his debt (μ), there is also a garnishment of part of the defaulter's earnings (ρ). The defaulter is not excluded from the risk-free market. V^D represents the value function for the period in which default occurs, and V^{AD} represents the value function for periods after default, when reorganization is required.

$$\begin{aligned} V^D(a,h,x,d,r,j) &= \max_{l,h',x'} \left[\frac{(w_j h(1-l)(1-\rho) + (1+r_f)x - x')^{1-\sigma}}{1-\sigma} + \beta V^{AD}(a,h',x',d',r',j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & \quad d' = d(1+\mu)(1+r),\ d > 0. \end{aligned} \tag{13}$$

$$\begin{aligned} V_j^{AD}(a,h,x,d,r,j) &= \max_{l,h',x'} \left[\frac{(w_j h(1-l) + (1+r_f)x - x' - p_{nc}(d))^{1-\sigma}}{1-\sigma} + \beta V^{AD}(a,h',x',d',j+1) \right] \\ & \quad s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & \quad d' = (d - p_{nc})(1+r),\ d > 0, j = 1,2,...,T'. \end{aligned} \tag{14}$$

Case 4: Not yet consolidated

In this case the agent can choose among the available schemes. He will maximize over the four possible choices.

$$\begin{aligned} V^{NoC}(a,h,x,d,r,j) &= \max_{l,h',x',p,d'} \frac{(w_j h(1-l) + (1+r_f)x - x' - p(d))^{1-\sigma}}{1-\sigma} + \beta E \max \\ & \quad \left[V^{NoC}(a,h',x',d',r',j+1), V^{SC}(a,h',x',d',r,j+1), \right. \\ & \quad \left. V^{AD}(a,h',x',d',r',j+1), V^{IC}(a,h',x',d',r',j+1) \right] \end{aligned} \tag{15}$$

$$\begin{aligned} & s.t.\ l \in [0,1],\ h' = h(1-\delta_{nc}) + a(hl)^{\alpha},\ x \geq 0 \\ & d' = (d-p)(1+r),\ p \in P, j = 1,2,...,T. \end{aligned} \tag{16}$$

Optimal repayment implies maximizing over these value functions. With the appropriate parameters and the estimated Markov process for loan rates, I solve for optimal choices within each repayment path and then dynamically pick the optimal repayment choice, $p_j^*(a,h,x,d)$, $\forall j = 5,6...,J$. Note that the function in Case 4 may not be concave in h, even if the four value functions in the maximum operator on the right-hand side of the equations are. I discuss this issue in Section 3.3, which describes the computational method used. Details are provided in the appendix.

[19] Under the program, if the defaulter delivers several regular payments, he regains his right to consolidate. For tractability purposes, however, I abstract from modeling this particular feature.

2.3 College Enrollment. Significant Trade-off

An agent from state (a, h, x) chooses to go to college if $V_C(a, h, x) \geq V_{NC}(a, h, x)$, where $V_{NC}(a, h, x)$ gives the maximum present value of utility if he chooses not to go to college, and $V_C(a, h, x)$ gives the maximum present value of an agent's utility if he chooses to go to college.

Within the model, the trade-off between the two paths arises from the distinction between human capital accumulation on the college path relative to the no-college path, which is threefold: 1) Human capital is not productive during college; 2) The rates at which human capital depreciates differ; 3) The growth rates of the human capital rental rate differ. As already mentioned in Section 2.2, the first assumption is in line with evidence that college students do not have jobs that value the set of skills they own, nor do these jobs improve students' earnings abilities after they graduate from college. The last two assumptions derive from calibrating the four parameters (depreciation rates, δ_c and δ_{nc} and wage growth rates, g_c and g_{nc}) to match earnings statistics in the PSID family files for the two education groups. The rental rate of human capital grows at a higher rate on the college path, but human capital depreciates faster, facts that are consistent with the empirical evidence (details are provided in Section 3.1). The elasticity parameter, α, is the same for both paths. While a higher value could be considered for the college path to allow for more productive human capital accumulation, this is already captured by the first feature. I discuss the implications of relaxing this assumption, however, in Section 3.1.

The functional form of human capital accumulation is the same on both paths in order to capture the effect of initial characteristics on college enrollment when running policy experiments. As a result, optimal human capital accumulation within my model dictates that early in the life-cycle, agents devote more time to human capital accumulation on both paths. What drives the incentive to accumulate human capital on the college path, however, are the higher returns to human capital investment. Moreover, the non-productivity of human capital during college pushes this time allocation to the maximum during these years. Both the higher growth rate and the higher depreciation rate of human capital induce agents to find it optimal to devote more time to human capital accumulation beyond college years. These incentives together with individual initial characteristics drive the results of the model. This approach correctly accounts for the trade-off between incentives to accumulate human capital on the two paths. To gain some intuition, consider an alternative where college students are allowed to work an exogenous amount of time at wages similar to those of high school graduates who do not attend college.[20] This will obviously be detrimental to human capital accumulation for the college group, which is consistent with the literature on college completion, as previously mentioned. In the context of this model, however, imposing a time limit for human capital accumulation during the first

[20] Average wage rates for college students represent 80 % of the average wage rates for high school graduates who do not enroll in college (Manski (1983)).

four years for college students (without an equivalent limit on the no-college path) will result in lower human capital stocks. Thus, earnings abilities for an agent who choose to enroll in college will fall over four years in college relative to the case where the agent had chosen not to enroll in college and, thus, accumulated human capital on the no-college path. While this may be true for some individuals with the same measured characteristics, it is not the case for the majority of high school graduates, as attested in Willis and Rosen (1979).

Finally, in this setup, agents are not borrowing constrained. If they choose to enroll in college, funds are available. An implication of this assumption is that, absent risk and leisure in the utility function, the college decision is based on simply maximizing the present value of earnings plus initial assets net of college tuition. Borrowing for college, however, is risky, since the interest rate on student loans is uncertain. Interest rates are serially correlated and thus affect consumption-smoothing behavior. As a result, risk aversion matters in my model, and so the problem is formulated as maximizing the present value of utility. At the same time, there is no incentive to enroll in college only because funds are available: student loans are fully used during the college period. Access to the risk-free market is available on both paths.

To this end, an important observation is that "endowments" in my model are as of the time people graduate from high school; thus, they may be partly or even mostly the outcome of the investment that have been made in the child from conception to high school. Studies have found that parental income (prior to high school) is a particularly significant correlate of endowments, arguably reflecting parental investment behavior (Keane and Wolpin (1997)). While the common wisdom is that human capital stock embodies school preparedness, and thus reflects parental investment in early education, in my setup I jointly estimate levels of ability and human capital stocks after high school to match life-cycle earnings. Thus, each of these characteristics may capture part of the individual's college preparedness. A richer version of this framework that allows for early education along with later education may decompose this effect and may account for complementarities between the two stages.[21]

3 Calibration

The calibration process involves the following steps: First, I assume parameter values for which the literature provides evidence, and I set the growth and depreciation rates to match the Panel Study of Income Dynamics (PSID) data on earnings for high school graduates and college graduates. For the policy parameters, I use data from the Department of Education. Second, I calibrate the Markov process for interest rates on loans, using the time series for 3-month Treasury Bills

[21]Early investments facilitate the productivity of later investment, but they are not productive if they are not followed up by later investments, such as college education (Caucutt and Lochner (2005) and Cunha et al. (2005)).

Table 1: Parameter Values

Parameter	Name	Value	Target/Source
β	Discount factor	0.96	real avg rate=4%
σ	Coef of risk aversion	2	Browning et. al. (1999)
r_f	Risk free rate	0.04	avg rate in 1994
J	Model periods	38	real life age 20-57
g_c	Rental growth for college	0.0065	avg growth rate PSID
g_{nc}	Rental growth for no-college	0.0013	avg growth rate PSID
δ_c	Depreciation rate for college	0.0217	decrease at end of life-cycle PSID
δ_{nc}	Depreciation for no-college	0.0101	decrease at end of life-cycle PSID
α	Production function elasticity	0.7	Browning et. al. (1999)
$\overline{d}$	College cost	31,775*	College Board
$\hat{d}$	Tuition cost per year in college	3813*	College Board
$t(a)$	Scholarship	$33\%\overline{d}$	DOE-NCES
T	Loan duration	10	DOE
λ	Fraction for income payment	0.04	DOE
ρ	Wage garnishment upon default	0.03	DOE
μ	Debt increase upon default	0.10	DOE

* This is in 1982-1984 constant dollars.

for 1980-1996. The third step involves calibrating the distribution of initial characteristics. For the initial asset distribution I use the Survey of Consumer Finances (SCF) 1983 and High School and Beyond (HB) 1980 data sets. Calibrating the joint initial distribution of learning ability and human capital is particularly challenging, given that there is no data counterpart. I find this distribution by matching statistics of life-cycle earnings in the March Current Population Survey (CPS) for 1969-2002. The model period equals one year.

3.1 Parameters

The parameter values are given in Table 1. The discount factor is 1/1.04 to match the risk free rate of 4%, and the coefficient of risk aversion chosen is standard in the literature. Agents live 38 model periods, which corresponds to a real-life age of 21 to 58. Statistics for lifetime earnings are based on earnings data from the March Current Population Survey (CPS) for 1969-2002 with synthetic cohorts. For each year in the CPS, I use earnings of heads of households age 25 in 1969, age 26 in 1970, and so on until age 58 in 2002. I consider a five-year bin to allow for more observations, i.e., by age 25 at 1969, I mean high school graduates in the sample that are 23 to 27 years old. Real values are calculated using the CPI 1982-1984. There are an average of 5000 observations in each year's sample. I divide education based on years of education completed with exactly 12 years for high school and those with 16 years of completed schooling for college. I also construct similar profiles using PSID family files for people age 25 in 1969 and followed until 2002. The sample includes 229 high school graduates. Among these, 49 have a college degree. The sample in the PSID is constructed similarly to the samples from the CPS using the five-year bin for age.[22] Figure A-3 in the appendix presents statistics by education groups for my samples (CPS and PSID), and the statistics across the two samples are similar. The statistics constructed using the PSID data do not look different from those from the CPS. I use the CPS data to construct earnings profiles to estimate the distribution of initial characteristics, since the sample size of the PSID is relatively small since it consists of only one cohort.

The rental rate on human capital equals $w_j = (1+g)^{j-1}$, and the growth rate is set to $g_c = 0.0065$ and $g_{nc} = 0.0013$, respectively. When I calibrate these growth rates, I follow the procedure in Huggett et al. (2006). I extend the PSID sample to include ages 25 to 58 in each year. The growth rates equal the average growth rates in average real earnings per person for high school graduates and college graduates over the period 1969-2002 in the extended sample. This is because within the model, the growth rate of the rental rate equals the growth rate of average earnings when rental growth and population growth are constant and the initial distribution of human capital and ability is time invariant. To calibrate g_c and g_{nc}, I track the annual means of growth rates of average earnings for the cross-section distributions. The underlying assumption is that, each year, 59-year-old high school graduates are replaced by 25-year-old high school graduates with the same initial human capital. With the time invariant initial human capital, the effect on the change in mean earnings comes solely from w. This procedure directly pins down growth rates in rental rates in human capital for the two education groups and is in line with the empirical evidence. Using PSID data, Guvenen (2007) examines income processes by education groups and finds major differences between college and high school educated people, including income growth rates. Using data from the 1979 youth cohort of the National Longitudinal Surveys (NLSY), Keane and Wolpin (1997) find that real wages increase at a higher rate after 21 years of age for white-collar jobs than for blue-collar jobs. They associate additional years of schooling with white-collar jobs. Gourinchas and Parker (2002) construct life-cycle profiles for consumption and income using the Consumer Expenditure Survey and also find different slopes for income for high school and college educated people. An alternative procedure would be to estimate a unique growth rate using data for high school graduates regardless of their college education and use it for both education groups. While this specification would make the model consistent with balanced growth observations, this would not be consistent with the data for the relevant period, which coincides with increases in skill premium and wage inequality. Studies

[22] There are no data on labor earnings for the years 1993-1995/2000, so I construct these using variables for thw wages/salaries of householdheads from main job, extra job, bonuses, tips, overtime, income from professional practice or trade, labor part of income from farm, business, market gardening, and room and boarders. There are no interviews for years 1998, 2000 and 2002, so data are missingfor labor earnings for the years 1997, 1999 and 2001. I use linear interpolation on those years when constructing life-cycle earnings profiles.

have shown that systematic differences in growth rates are the major force behind this rise.[23] Given the growth in the rental rates, I set the depreciation rates to $\delta_c = 0.0271$ and $\delta_{nc} = 0.0101$, respectively, so that the model produces the rate of decrease of average real earnings at the end of the working life-cycle, documented in Figure A-3.[24] The model implies that, at the end of the life-cycle, negligible time is allocated to producing new human capital and, thus, the gross earnings growth rate approximately equals $(1+g)(1-\delta)$. When I choose the depreciation rates on this basis, the values lie in the middle of the estimates given in the literature surveyed by Browning et al. (1999). My estimates are in line with the observation that skills used by college graduates depreciate more rapidly than skills used by high school graduates (Keane and Wolpin (1997)).

I set the elasticity parameter in the human capital production function, α, to 0.7. Estimates of this parameter are surveyed by Browning et al. (1999) and range from 0.5 to almost 0.9. I vary α within this range and a 0.7 value best fits the college enrollment percentage within my sample. This is consistent with recent estimates in Huggett et al. (2007).[25] Higher values will deliver more steeply sloped age-earnings profiles, especially for college graduates given higher ability levels for this group. The positive correlation between ability and human capital lifts up the age-earnings profiles of high-ability agents relative to low-ability agents and hence delivers a higher college enrollment percentage for higher values of α.

The fraction of income used as payment under the income-contingent plan, the duration of the loan, and the penalties upon default are set according to the Department of Education. Under the FSLP, the fraction of income, λ, used as payment under the income-contingent plan is based on the income level, the principal, and the interest rate at consolidation time. The fractions of income under the actual program increase with the level of debt, decrease with the level of income, and increase with the interest rate. Payments are generally capped at an amount slightly less than the required payment under a standard schedule and cannot be less than \$5. I set this parameter in the middle of estimates in Ionescu (2008), where the values of fractions are computed using the payment calculator provided by the Department of Education. Following Ionescu (2008), I set the penalties upon default, the wage garnishment, $\rho = 0.03$ and the increase in debt level upon default, $\mu = 0.10$. In practice these punishments vary across agents, depending on collection and attorney's fees, and can be as high as 10-25 % respectively.[26] The guideline for

[23]Murphy and Welch (1992) use CPS data from 1964 to 1998 and find an increase in the college premium from 45% to 80%. Heckman et al. (1998a) use different wage growth rates (as estimated by Katz and Murphy (1992)) in the context of a Ben-Porath framework to explain the rising wage inequality in the 1980s.

[24]I use rates of growth in earnings at the end of the life-cycle for the two education groups to set depreciation rates equal to 0.0217 and 0.0101, respectively. The growth rate in mean earnings at the end of the life-cycle from Figure A-3 is -0.02077 for college graduates and -0.01006 for no-college.

[25]I also tried a higher value for the college group relative to the non-college group as suggested by Browning et al. (1999), but this induces a higher enrollment rate within my model relative to the data.

[26]The Debt Collection Improvement Act of 1996 raised the wage garnishment limit to 15 % of the defaulter's

defaulting borrowers does not provide an explicit rule for these penalties. Lochner and Monge (2008) set the wage garnishment punishment at 10 %. They do not model, however, the increase in debt punishment. The value I estimate delivers a wage garnishment that is lower than the amount the borrower would have paid if he had not defaulted.

The maximum loan amount is based on the full college cost, $\overline{d}$, estimated as an enrollment-weighted average (for public and private colleges) and transferred in constant dollars using the CPI 1982-1984.[27] The same procedure is used to estimate direct college expenditure, which represents 31% of the full college cost at public universities and 67% at private universities. The enrollment-weighted average of tuition cost is 48% of the full college cost. The tuition for each year in college, $\hat{d}$, is \$3,813 in constant 1982-1984 dollars (\$15,252 for the entire college education). Thus, students pay $\hat{d}$ during each year in college and are eligible to borrow up to $\overline{d} - (x_p + 0.2 * x_s)$ with x_p, the parental contribution for college, which represents 40 % of the initial assets x_1 and the remainder x_s, student's own assets.[28] According to the NCES data, 12% of college students, on average, received merit-based aid over the past several years, the major source being institutional aid. To set merit aid, $t(a)$, I use the Baccalaureate and Beyond (B&B) 93/97 data set with college graduates from 1992-1993. The sample consists of 7,683 students. The amount of financial aid received increases by GPA quartiles with an average of 12 % of the total cost for the bottom GPA quartile and an average of 63 % of the total cost for the top GPA quartile. The percentage of students who receive merit-based aid also increases by GPA quartiles. On average, merit aid represents almost 33% of the cost of college.

3.2 Rate Loan Process

The interest rate on educational loans is set to equal the Treasury bill rate plus a threshold of 2.3%.[29] The rate follows a stochastic process, given by a 2 by 2 transition matrix $\Pi(R^{'}, R)$ on $\{\underline{R}, \overline{R}\}$, calibrated to match the Treasury bill rate in the 1990s. To estimate the stochastic process for loan rates, I use the time series for 3-month Treasury bill for 1980-1996, adjusted for inflation. I fit the time series with an AR(1) process: $R_t = \mu(1-\rho)+\rho R_{t-1}+\varepsilon$, $\varepsilon \sim N\ (0, \sigma^2)$. The estimates of the two moments are given by $\rho = 0.9038$ and $\sigma = 0.7788$. I aggregate this to annual data; the autocorrelation is given by 0.297 and the unconditional standard deviation by 1.817. I have approximated this process as a two-state Markov chain. The support is $R \in \{1.038, 1.075\}$.

pay.

[27]The enrollment-weighted cost for college was \$53,855 in 2000-2004 for private universities and \$20,900 for public universities in constant 1982-1984 dollars. Among the students enrolled, 67% went to public and 33% to private universities. The enrollment-weighted average cost is \$31,775 in constant dollars.

[28]According to the Department of Education, 20 % of the student's assets are considered available funds for college and entered in the EFC formula.

[29]This matches the mark-up set by the government for subsidized loans issued before 2006 with variable interest rates capped at 8.25% or less.

The transition matrix is $\begin{bmatrix} 0.65 & 0.35 \\ 0.35 & 0.65 \end{bmatrix}$.

3.3 Distribution of Asset, Ability and Human Capital

First, for the asset distribution, I combine two data sets, SCF and HB. I get a mean of $23,100 and a standard deviation of $32,415 in 1984 constant dollars. In the SCF data, the sample consists of 174 individuals, 18-20 years old. Assets include paper assets, the current value of their home, the value of other properties, the value of all vehicles, the value of business where paper assets are given by the sum of financial assets, the cash value of life insurance, loans outstanding, gas leases, the value of land contracts and thrift accounts. This component represents, on average, 20 % of inital assets in the model. In the HB data, the sample consists of 3721 seniors in high school. I use their expected family contribution for college. This component represents the remainder of the 80 % of initial assets in the model. An important finding from the HB data is that the expected family contribution in the HB data is not different across groups of students that eventually enroll or not in college.

Second, I calibrate the joint initial distribution of ability and human capital to match key properties of the life-cycle earnings distribution in the CPS 1969-2002 data.[30] To carry out this procedure, I extend the method developed by Huggett et.al. (2006) on the Ben-Porath framework. In contrast to their paper, additional features in my model impose a more intensive computation procedure, which in turn requires a more complex algorithm. In particular, four complications arise when applying this approach to my model. First, optimal decision rules for human capital accumulation cannot be separated from other choices in my model. Higher savings might trigger less time devoted to market work and more time to human capital accumulation. Thus, on both the college and no-college paths, I jointly solve for the optimal human capital and savings decision rules. On the college path, optimal repaying and borrowing also affect optimal allocation of time. A higher or lower debt level induces agents to exert higher or lower work effort. Similar effects may arise from the availability of more or less flexible repayment schemes. To keep computations tractable, I break the problem into smaller sub-problems in terms of the time framework. Second, given several options for repayment, the concavity of the value function on the no consolidation path, V^{NoC} (Equation 16), may be problematic, since it includes the maximum over four continuation value functions. When there are discrete choices (like whether to default or not), the value function may not be concave. This can make the default behavior very sensitive to changes in current income or debt, which in turn makes finding the equilibrium default premium problematic, as in Chatterjee et al. (2007). Since I am not

[30] I assume no correlation between initial asset and ability or initial human capital. Section 4.2 shows that this does not seem to be restrictive and discusses the implications of relaxing this assumption.

solving for equilibrium prices, I do not have the latter problem. However, it may still be the case that my results (in terms of the frequency of default) may be sensitive to the fineness of the grid.[31] The third source of difficulty arises from the fact that the interest rates on student loans are serially correlated. This affects consumption-smoothing behavior. Therefore, risk aversion matters in my model, and thus, agents do not simply maximize the present discounted value of earnings as in Huggett et al. (2006). This feature along with the already large state vector requires additional adjustments of the algorithm.[32] Fourth, the education choice also affects earnings profiles for high school graduates. After solving the time allocation problem for each education level, I compute the optimal enrollment decision to estimate the earnings profiles for high school graduates within my model. The appendix describes details on the computation procedure used to carry out these steps.

The earnings distribution dynamics implied by the model are determined in several steps. First, I compute the optimal decision rules for human capital using the parameters described in Table 1 for an initial grid of the state variable. Second, I solve for the enrollment decision and compute the life-cycle earnings for any initial pair of ability and human capital. Last, I choose the joint initial distribution of ability and human capital to best replicate the properties of the U.S. data documented in Figure A-3.

Using a parametric approach, I search over the vector of parameters that characterize the initial state distribution to minimize the distance between the model and the data. I restrict the initial distribution on the rectangular grid in the space of human capital and learning ability to be jointly, log-normally distributed. This class of distributions is characterized by 5 parameters. In practice, the grid is defined by 20 points in each dimension. I find the vector of parameters $\gamma = (\mu_a, \sigma_a, \mu_h, \sigma_h, \rho_{ah})$ characterizing the initial distribution that solves the minimization problem below,

$$\min_{\gamma} \left(\sum_{j=5}^{J} |log(m_j/m_j(\gamma))|^2 + |log(g_j/g_j(\gamma))|^2 + |log(d_j/d_j(\gamma))|^2 \right) \tag{17}$$

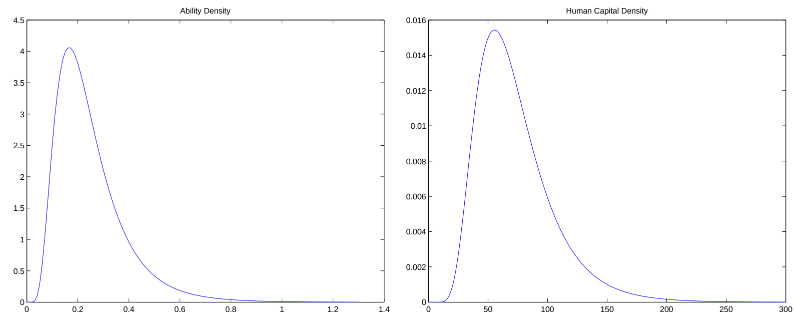
where $m_j, g_j,$ and d_j are mean dispersion and inverse skewness statistics constructed from the CPS data, and $m_j(\gamma), g_j(\gamma),$ and $d_j(\gamma)$ are the corresponding model statistics. Overall I match 102 moments. Figure 2 illustrates marginal densities for the learning ability and initial human capital stock for high school graduates.

Figure 3 illustrates the earnings profiles for high school graduates for the model versus CPS data when the initial distribution is chosen to best fit the three statistics considered. In my

[31] A solution for overcoming the non-concavity problem with discrete choices involves adding idiosyncratic earnings shocks (see Gomes et al. (2001) for a discussion on the issue). My model and computation algorithm impose a different approach for dealing with the non-concavity problem (see the appendix for details).

[32] The discretization of the state space in my algorithm implies 1,440,000 grid points, whereas in Huggett et al. (2006) the state space consists of 1600 grid points. For a comprehensive discussion of "the curse of dimensionality" problem see Amman et al. (1996).

Figure 2: Marginal Densities



(a) Ability Density (b) Human Capital Density

model, I obtain a fit of 5.3% (0% would be a perfect fit). The model performs well given the institutional details and additional decisions that I need to account for relative to the standard Ben-Porath model, for which Huggett et al. obtain a fit of 5.2% (for the same value of the elasticity parameter $\alpha = 0.7$).[33] Details on the initial distribution characteristics together with a comparison to Huggett et.al. (2006) using the Ben-Porath model are given in Appendix A-3.

4 Results

In Section 4.1, I discuss the significance of learning ability, initial human capital stock, and parental wealth for human capital accumulation and college enrollment in the benchmark economy.[34] In Section 4.2, I present the model's predictions for college enrollment, default, and life-cycle earnings in the benchmark economy. Last, I discuss policy effects in Section 4.3.

4.1 Who Goes to College? Significance of Initial Heterogeneity

I first consider a simple example to gain intuition regarding the relevance of initial conditions along with key features of the model. Then, I present the results of the full model, which are twofold: 1) a combination of high-ability and low-human capital determines the decision to enroll in college, and 2) even though a lower initial asset level makes the college path a riskier choice, my results imply that initial assets have minimal effect on college participation.

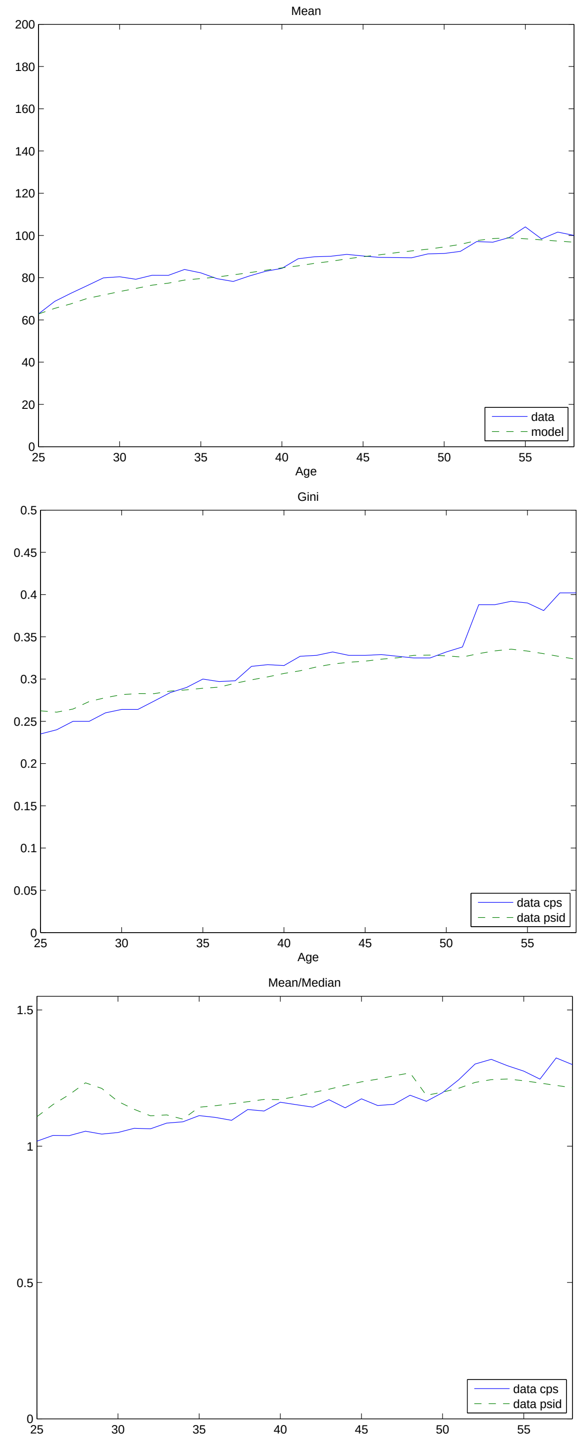
[33] As a measure of goodness of fit, I use

$$\frac{1}{3J}\left[\sum_{j=5}^{J}|log(m_j/m_j(\gamma))| + |log(g_j/g_j(\gamma))| + |log(d_j/d_j(\gamma))|\right]$$

This represents the average (percentage) deviation, in absolute terms, between the model-implied statistics and the data.

[34] Benchmark supposes no consolidation with variable interest rate payments and the option to default.

Figure 3: Statistics of Earnings Profile



4.1.1 A Simple Example

Consider a two-period example where investing in human capital in the first period is the only choice on both the college and the no-college paths; there is no savings decision and everything is consumed in the second period. On the college path, agents repay college loans at an interest rate that is realized in the second period. There are no repayment options available. In this simplified setup, decision rules for human capital investment for an agent of ability a and initial human capital stock h_1 are dictated by the following marginal conditions:

$$
\begin{aligned}
\text{no college} : \frac{u'(c_1)}{u'(c_2)} &= \frac{\beta(1+g_{nc})\alpha a(h_1 l_1)^{\alpha-1}}{h_1} \\
\text{college} : \frac{u'(c_1)}{E_r u'(c_2)} &= \beta w_1(1+g_c)\alpha a(h_1 l_1)^{\alpha-1}.
\end{aligned} \tag{18}
$$

These conditions reveal several key features: 1) On both paths, agents are willing to sacrifice more current consumption if the growth rate of wages is higher. Thus, with $g_c > g_{nc}$, agents with the same initial characteristics invest more on the college path. 2) The level of wages that agents receive matters for the college path, whereas on the no-college path, it does not. This is a consequence of the fact that human capital is not productive during college. Thus, agents with the same initial characteristics have the incentive to invest more in their human capital on the college path. This particular period coincides with the fourth period in the full model. For the other periods in the full model, the wage level does not matter; only the growth rates of wages matter. 3) On both paths, high-ability agents have the incentive to sacrifice more current consumption and invest in their human capital (keeping everything else constant). Given features 1) and 2), high-ability agents are better off investing on the college path. They benefit from the high growth rate of wages and the wage level in the first period after graduation. 4) On both paths, agents with low-human capital stocks have the incentive to sacrifice more consumption and invest more in human capital relative to agents with high-human capital stocks. Again, given features 1) and 2), agents with low-human capital stocks are better off on the college path. A subtle point is that when two agents with different human capital stocks (and everything else constant) are compared, the agent with low-human capital stock sacrifices less consumption than the agent with high-human capital stock on the college path relative to how much less consumption he would have sacrificed relative to the high-human capital stock agent if both had been on the no-college path. This results from the fact that human capital is not productive during college.[35]Also note that in the case the growth rates of the rental rates are the same,

[35]This feature is not present in Huggett et al. (2006), where without ability differences, all agents within an age group produce the same amount of new human capital regardless of the current level of human capital. In an updated framework that accounts for human capital risk, however, ex-ante identical agents differ ex-post in human capital and earnings (see Huggett et al. (2007)). In contrast, my model produces these differences through

$g_c = g_{nc}$, agents with high-ability and low-human capital still prefer the college path, given feature 2).[36] 5) There is interest rate uncertainty only on the college path. In this example, given that interest rates do not matter during the college period, the problem could be reduced to simply maximizing the present value of earnings minus tuition costs. For every period after college, this is not the case anymore, unless interest rates are i.i.d. As previously mentioned, given serially correlated rates, utility maximization in my setup cannot be reduced to maximizing the discounted value of earnings net of tuition.

4.1.2 Ability versus Human Capital

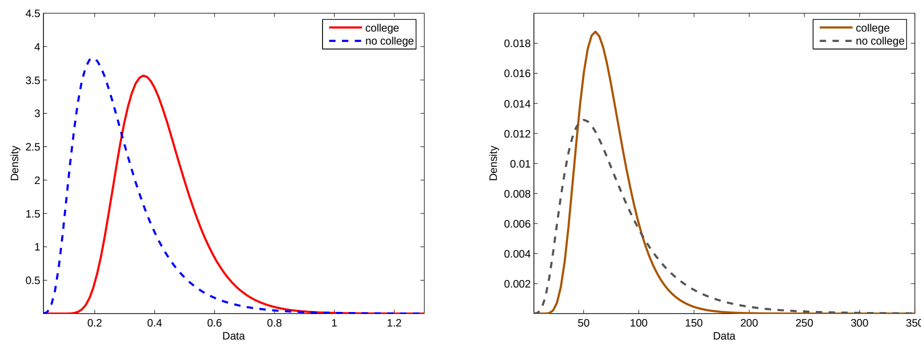
As the simple set-up reveals, there is a trade-off between ability and human capital that makes college a worthwhile investment. A high-ability high school graduate takes advantage of this investment opportunity with high returns. At the same time, the market values human capital if the agent chooses to work, and a low level of human capital stock implies a low cost of investing in college. Figures A-4 and A-5 in the appendix present life-cycle human capital profiles for the college path versus the no-college path. Absent heterogeneity in human capital, high-ability agents have steeper profiles of human capital accumulation than low-ability agents on both the college and the no-college paths; this is evident in Figure A-4. high-ability agents have the incentive to devote most of their time early in the life to human capital accumulation regardless of the available technology. They choose the college path because the addition to human capital stock offsets depreciation. Additionally, for any ability level, agents dedicate even more time to human capital accumulation on the college path relative to the no-college path: the left panel of Figure A-4 presents steeper profiles relative to the right panel across all levels of ability. This is explained by the high growth rate in rental rate on this path. In contrast, Figures A-5 in the appendix show that absent heterogeneity in ability, agents with high levels of human capital stock have flatter profiles of human capital accumulation than agents with low levels on both the college and the no-college paths (left and right panel, respectively). Their incentive to invest in human capital earlier in life is not as high as for agents with low-human capital. With a lower depreciation rate on the no-college path and the non-productivity of human capital during college, high-human capital agents are better off on the no-college path even with lower growth rate in the rental rate. The no-college path in general induces flatter profiles of human capital accumulation for an agent of a given human capital stock relative to the college path.

The prediction of the model that a combination of high enough ability levels and low enough human capital stocks drives the decision to enroll in college may seem counterintuitive. As previously mentioned, evidence shows that the amounts of money parents spend on early edu-

college enrollment and risk associated with college financing.

[36]In the full model, these incentives are also induced by the differential in the depreciation rates of human capital on the two paths, a feature that the simplified example does not capture.

Figure 4: Marginal Densities Conditional On Enrollment Decision



(a) Ability

(b) Human capital

cation to provide a better learning environment, contribute to a better preparedness for college, as embedded in human capital stock. The model does not contradict this fact. The average human capital stock for people who enroll in college is 75.2 and the average for the no-college group is 72.4. Regarding ability levels, the model predicts an average of 0.396 for the college group relative to an average of 0.217 for the no-college group. This is because human capital and ability are strongly correlated, which is consistent with empirical evidence that positively links cognitive and noncognitive skills. With ability being the driving force, the model delivers higher levels, on average, of both ability and human capital for the college group relative to the no-college group. The percent of people who enroll in college is much higher for high-ability quartiles and middle human capital quartiles (Table 2). Figure 4 shows the marginal densities of ability and initial human capital stock conditional on college enrollment. Graphs are drawn for an average level of initial assets and are robust to changes therein. The fact that ability matters more than human capital is consistent with Huggett et al. (2006), who find that ability plays a crucial role in matching life-cycle earnings. In particular, ability accounts for a significant part of the variance in present discounted earnings. Also, there is evidence that students' ability levels matter for college enrollment, whereas college preparedness is essential for college completion, but it does not drive the decision to enroll in college (Manski (1983), Tinto (1993), and Stinebrickner and Stinebrickner (2007)).[37] Finally, as mentioned before, endowments in this economy are as of the time of high school graduation. Thus, both characteristics may capture some of the early investments parents make in their children.

[37] I assume that everyone who enrolls in college graduates. I restrict enrollment to be a dichotomous choice. I abstract from modeling either college completion or heterogeneity to focus on the relationship between college investment, financing and default. College completion and heterogeneity, however, are relevant for enrollment and borrowing behavior as shown in studies by Avery and Hoxby (2002) and Dynarski (2003).

Figure 5: College Enrollment by Initial Heterogeneity

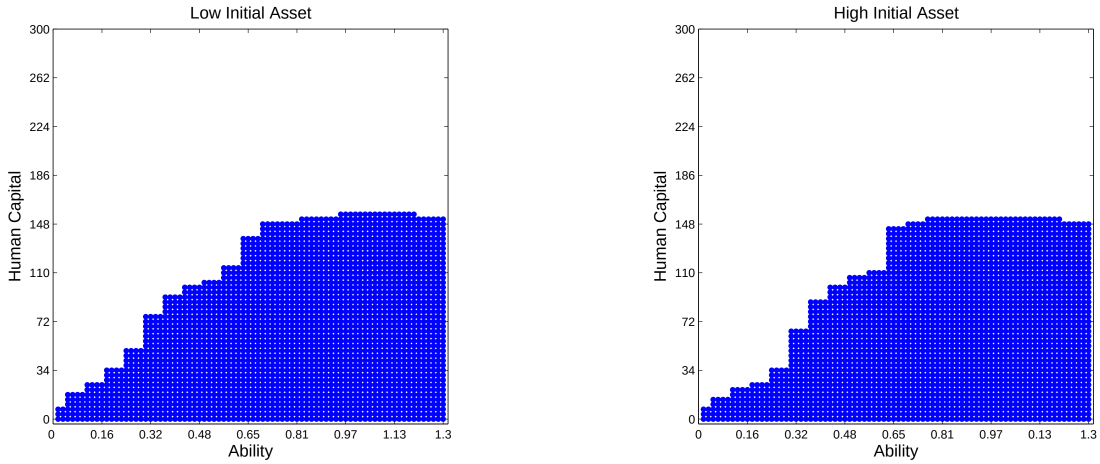


Table 2: College Enrollment Percentages by Quartiles of Initial Characteristics

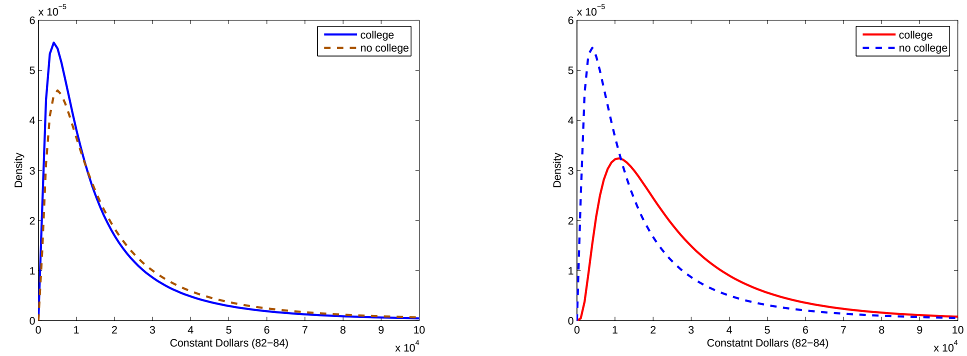
Characteristic	Q1	Q2	Q3	Q4
Ability	0	0.2	19	51.7
Human capital	8.5	23	26	17
Assets	21	19	18.7	16.5

4.1.3 Does Parental Wealth Matter?

Figure 5 illustrates the model's prediction for college enrollment based on learning ability and initial human capital stock for two levels of initial wealth (low wealth on the left, and high wealth on the right). For a given combination of ability and human capital, a change in initial assets will not alter the decision to enroll in college. The intuition behind this result is that many eligible high school graduates decide not to enroll in college if their return to college education would be too low to compensate them for earnings forgone during college. Either they lack the necessary ability or their human capital levels are too high. Hence, college investment is not attractive. The model delivers similar averages of initial assets for the college and the no-college groups ($21,600 versus $23,400, respectively). It predicts similar percentages of people who enroll in college across quartiles of initial assets (Table 2).

In my calibration, I assume no correlation between initial assets and ability or human capital. When I consider possible correlations, college enrollment is not affected. Picking the asset distribution exogenously with respect to ability and human capital does not seem restrictive. Given the initial joint human capital and ability distribution, when wealth is randomly assigned, that is, independent of ability and human capital (as I assume in all the exercises), there is

Figure 6: Asset Densities



(a) Initial assets are independent of ability and human capital

(b) Initial assets are highly correlated with ability and human capital

no correlation between wealth and enrollment. Figure 6(a) shows no difference for densities of initial assets for the two groups conditional on college enrollment. When I assign high wealth to high-human capital and ability, however, wealth and enrollment are highly correlated, as Figure 6(b) shows. I conclude that wealth does not drive the college decision. Rather, the combination of human capital and ability induces the agent to go to college. While it is true that more people from higher income groups enroll in college (see Figure A-2 in the appendix), this fact should not be necessarily attributed to income alone. A high correlation between wealth and human capital might provide a better explanation for the enrollment differential. The skills, ability and human capital acquired by the time the high school graduate decides to pursue college education are far more important than parental income in the college-going years.[38] College funds are readily available with the FSLP. If the individual lacks the necessary ability to benefit from college participation, extra funds for the prospective college student have little effect on his enrollment decision.

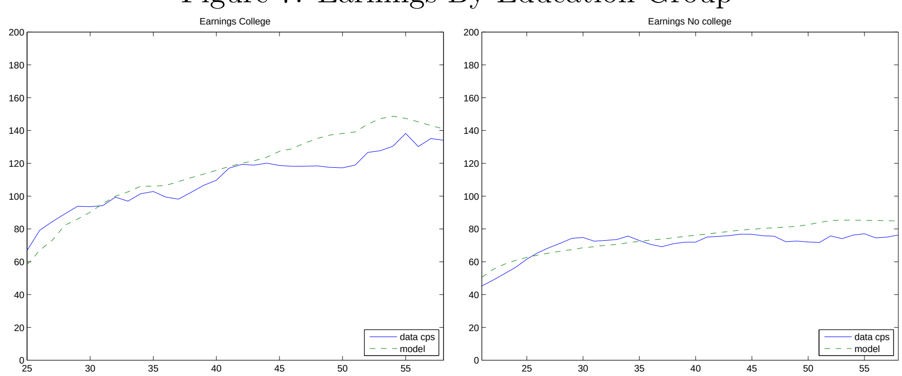
4.2 College Enrollment, Default and Life-Cycle Earnings

The model predicts that 18.9% of agents will enroll in college in the benchmark case when fluctuating payments and default are allowed. Autor et al. (1998) report a college percentage of 20.9% and the CPS sample produces 21.4%. Conditional on enrollment, the model predictions in the benchmark case are consistent with data for life-cycle earnings for college graduates and high school graduates who do not go to college, as Figure 7 shows. The model replicates the steeper earnings profile for the college group relative to the no-college group, with a college premium of 1.51. In the CPS, the average college premium is 1.5. Murphy and Welch (1992) estimate

[38] This is in line with research by Cameron and Taber (2004), Carneiro and Heckman (2002), Caucutt and Lochner (2005), and Keane and Wolpin (2001).

an average college premium of 1.58. The model also mimics earnings early in the life-cycle for high school graduates who do not enroll in college. For the no-college group, I extend the CPS data from 1969 to 1965 to construct earnings profiles for people aged 21 to 24. Earnings profiles within the model are constructed from simulated earnings of high school graduates who choose to work and not go to college for periods $j = 1, ..., 4$. This is interpreted as the opportunity cost of going to college. As Figure 7 shows, the model replicates the shape of earnings during this period. It overestimates, however, earnings levels for the first few years in the job market for the no-college group and underestimates them for the first few years in the market for the college group. A version of this environment with risky college education contingent on human capital stock may correctly account for the market entrance levels of earnings. Absent college risk, there are some students for whom college seems a worthwhile investment, since they have sufficiently low levels of human capital. If college risk is added, however, they may be better off not going to college. They will still find it worthwhile to invest in their human capital on the no-college path earlier in the life-cycle, given low levels of human capital stock. This will lower earnings profiles induced by the model for the first few periods on the no-college path. On the college path, with the low-human capital people out of the pool, the opposite is true.

Figure 7: Earnings By Education Group

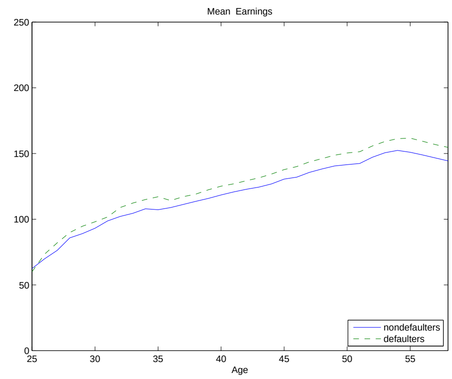


The model delivers a default rate of 12.8 %, which is computed as a default rate within 2 years after graduation.[39] Figure 8 presents life-cycle earnings for college graduates who default on their loans versus those who choose not to default. Defaulters have higher earnings, on average, with a slightly steeper profile. This is because, within the model, default implies a delay in payment for one period, during which some of the defaulter's wage is garnished. My simulations show that the wage garnishment ranges from 45 to 91 % of the payment that would have been delivered without default. Thus, during the default period, borrowers get a payment relief, which allows

[39]U.S. Department of Education uses a 2-year basis cohort default rate (CDR) as a primary measure (the percentage of a cohort of borrowers who are in default 2 years after entering repayment). The CDR understates the default problem and other measures, such as longer period average default rates are possible. Given the purpose of the current study, the data set used, and my model, the limitations of the CDR are not restrictive.

them to supply less time to the labor market and invest more in their human capital, which in turn increases their life-cycle earnings. When comparing lifetime earnings, defaulters earn 5 % more than non-defaulters. Ability levels of defaulters are 5.2 % higher on average than ability levels of non-defaulters and their human capital stock is 4 % higher on average.

Figure 8: Earnings Profiles for Defaulters versus Non-defaulters in the Model



4.3 Policies under the FSLP

The main goal of the paper is to evaluate the quantitative effects of two recent changes in the student loan program: (1) The introduction of the consolidation program in 1986, which allowed for more flexible repayment schemes. This change allowed college graduates to switch repayment plans or lock-in interest rates at any time during the repayment phase of the loan; and (2) The relaxation of the eligibility requirements policy in 1992, which modified the federal needs analysis for calculating the expected family contribution (EFC). In particular, home equity for the primary residence was no longer considered an asset for the EFC.[40] This policy change led to a lower average EFC for most students, particularly for those in middle and high-income families, resulting in more students from middle and high-income families who qualified for federally subsidized loans and for larger amounts. Consequently, it changed the composition of borrowers.

4.3.1 Implications for Enrollment, Default and Life-Cycle Earnings

The effects of these two policy changes on college enrollment and default relative to the benchmark model are presented in Table 3. The flexible repayment policy experiment opens up the possibilities to switch to standard consolidation and income consolidation in addition to the no consolidation and default options available in the benchmark economy. This induces an increase in college enrollment from almost 19 % to 23 % and a substantial decline in default rates. More

[40] In addition, parents with annual income of $50,000 or less or those who filed a short federal income tax form were not required to report assets. The minimum contribution from students was eliminated, and the amount expected from student earnings was reduced.

Table 3: Effects on College Enrollment and Default

	Enrollment Percentage	Default Rate
Benchmark	18.9%	12.8%
Flexible repayment	23.2%	2.7%
Relaxed eligibility	18.95%	12.6%

flexible repayment induces non-attendees with high-ability levels to participate in college. Thus, the returns to education are higher for high-ability students and compensate them for the forgone earnings for periods spent in college.

Figure 9: College Enrollment Under Flexible Repayment versus Benchmark

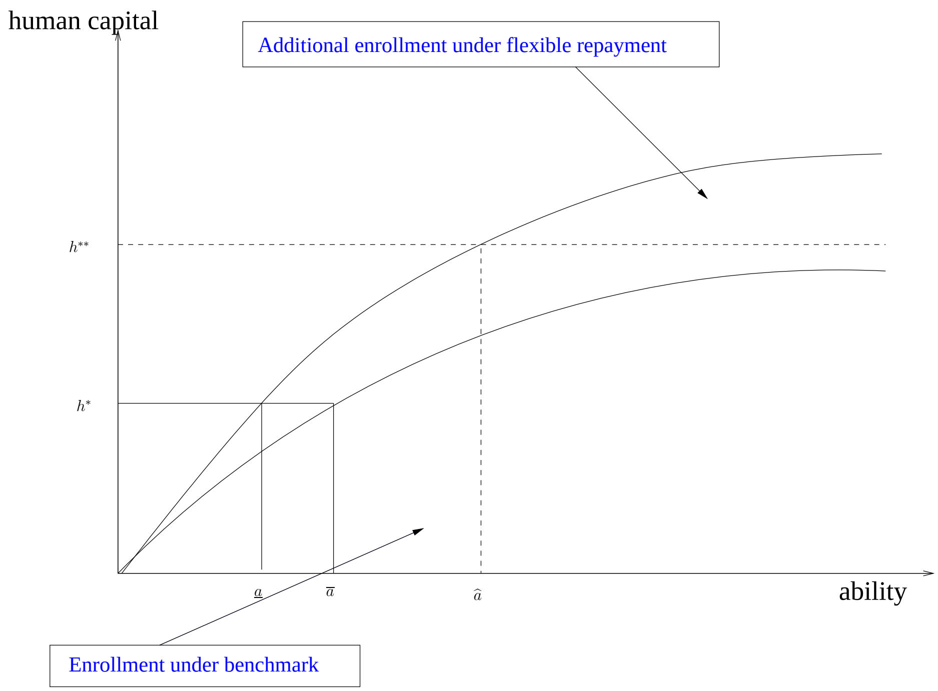
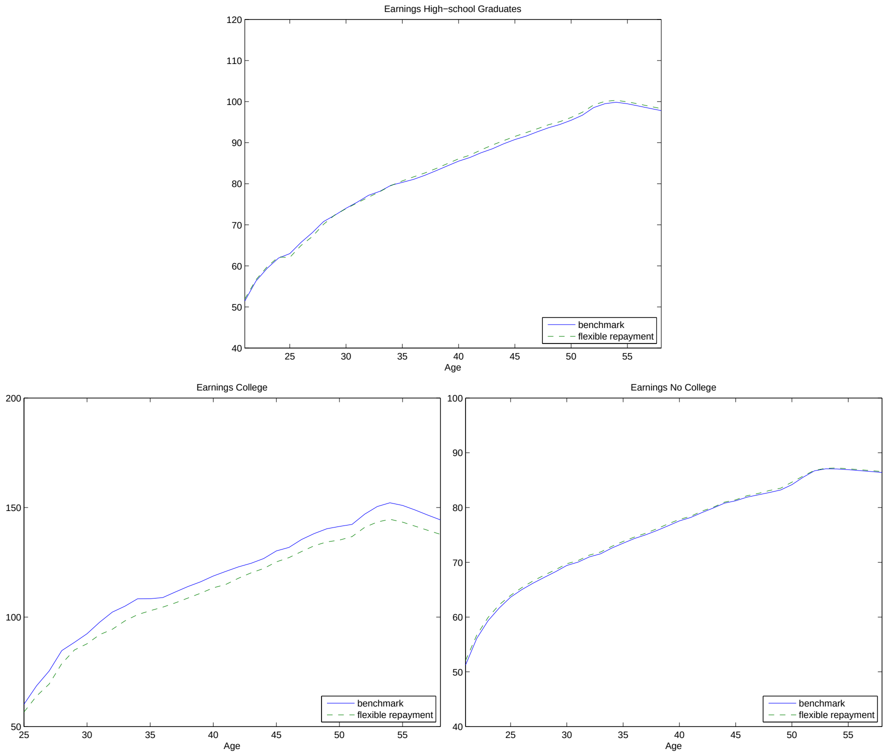


Figure 9 illustrates the mechanism of the model regarding the additional pool of college students: the area under the lower curve represents college enrollment in the benchmark economy and the area between the two curves represents additional college enollment in the flexible repayment system. Consider first an agent of ability level h^*. He is indifferent between going to college or not in the benchmark economy, at the ability level $\overline{a}$. With the flexible repayment policy, this ability threshold declines to $\underline{a}$. Given more generous repayment schemes, a lower ability level is sufficient to compensate for the same forgone opportunity. This channel decreases the average ability level for the college group. In contrast, an agent of ability level h^{**} never chooses to attend college in the benchmark economy. His human capital stock is too high, and thus, even if he is endowed with the highest ability level, he does not find college a worthwhile investment. With the flexible repayment, however, if his ability level is high enough, $(a \geq \hat{a})$, he chooses

Figure 10: Life-Cycle Earnings: Benchmark versus Flexible Repayment



to enroll in college. This channel increases the average ability level for the college group. The model predicts that the first effect dominates and the policy reform delivers a decrease in average ability for the college group. Another important observation is that for any fixed level of ability, a higher level of human capital stock is needed to make the agent indifferent between going or not going to college. Flexible repayment counteracts the negative effect of the opportunity cost of attending college for the same level of ability. The model predicts a small decline in average human capital for the college group. Agents who do not go to college have lower ability levels, on average, relative to the no-college group in the benchmark economy; high-ability agents choose to enroll. The gap in human capital levels between the college and no-college group is reduced.[41]

As a result, the policy that allows for flexibility in repayment induces changes in life-cycle earnings for the two education groups (Figure 10). The policy delivers lower earnings, on average, for college graduates (4.7 % lower relative to the benchmark) and higher earnings for high school graduates who do not enroll in college (0.5 % higher relative to the benchmark). The earnings profile for the college group is flatter than in the benchmark economy, given lower average levels of ability. Earnings profiles for high school graduates are 0.4 % higher, on average, and steeper relative to profiles in the benchmark economy, since there are more college graduates.

[41]These findings are in line with research by Kane (2003), who assesses the price elasticity of college enrollment decisions and presents evidence for students at the margin between enrolling and not enrolling.

Flexibility in repayment delivers a decline in default rates of 10 percentage points. This arises from the possibility to lock-in interest rates, which allows graduates to hedge against interest rate risk, and the availability of the income-contingent scheme, which allows college graduates to lower their payments, in particular low-income students.

Now I analyze the effects from relaxing eligibility requirements. It is modeled to mimic the redefinition of the expected family contribution (EFC), which no longer includes home equity. According to SCF data, the value of the primary residence represents 31.5 % of household assets (see Federal Reserve (2001)) and according to the Department of Education, 12 % of parental assets are considered available funds and enter the EFC formula. Thus, in the context of the model, this policy means that parental contribution to college is reduced to 0.12*0.685 from the level of parental contribution available in the benchmark economy. This policy change results in more students qualifying for student loans and in larger amounts. The model predicts, however, that the policy has little effect on enrollment or default rates. In the benchmark economy, the neccesary funds for college education are available. Thus, relaxing eligibility requirements does not affect college enrollment. Also, wealthier agents enroll in college regardless of the source of funds if they find the investment worthwhile. Even though less financially constrained high school graduates have more access to college loans, there is no major impact on default. This is explained by the availability of other repayment options together with the severity of the consequences of defaulting on student loans. Effects on life-cycle earnings are negligible.

To evaluate these policy experiments, I look at the changes in enrollment and default rates after each of these policy reforms occurred. In particular, for the first policy experiment, I consider the change in the average enrollment rate from 1981-1986 to 1987-1992, which represents an increase of 6 percentage points, and for the second policy the change from 1987-1992 to 1993-1998, which represents an increase of 4 percentage points.[42] The model predicts that a policy which allows for flexibility in repayments accounts for 70 % of the increase in college enrollment, whereas the second policy does not account for any of the increase in college enrollment. An important observation is that the total financial aid to higher education changed significantly for the periods in question, thus inducing various incentives to enroll. Financial aid declined by 25 % from 1980 to 1986 and increased by 61 % from 1986 to 2004 with most of the increase in the past 10 years.

To evaluate the two policy experiments relative to default rates, I look at the changes in the average cohort default rate (CDR) from 1988-1990 to 1991-1994 for the first policy experiment, and from 1995-1996 to 1997-1998 for the second policy experiment. Data show a decline of 7.8

[42] The first policy came into effect in 1987 and the second policy in 1993. Periods are chosen between the HEA in 1980, which reinstated the student loan program based on financial need, and the HEA in 1998, which involves other significant changes in the program that are not the subject of the current study. The average enrollment for 1981-1986 was 54 %. The college enrollment rate is lower in the benchmark economy, which is calibrated to the CPS 1969-2002 and does not include college dropouts.

percentage points for the former change and a decline of 6 percentage points for the latter.[43] The first policy experiment delivers a decline of 10 percentage points, while the second experiment does not account for any of the decline in the data. For the first period, since there is no data on how much of the decline in the default rate is accounted for by college graduates and how much by college dropouts, it could be the case that the decline in the default rate induced by flexibility in repayment was higher for college graduates than for dropouts. Studies have shown that dropouts are more likely to default on student loans (see McMillion (2004)). For the second period, the nondischargeability rule for student loans overlapped with the relaxation of eligibility requirements.

4.3.2 Consequences for Government Budget

Whether a policy is judged as effective depends on the original objectives, the welfare consequences, and the implications for government budgets. The two policy changes were initiated partially as a response to high default rates in the early 1990s and partially as a means to encourage college enrollment. The rate of default has declined substantially since then and college enrollment has increased steadily, with both policies potentially inducing these incentives. On the one hand, more flexibility in repayment helps students hedge against interest rate risk and lower their payments, inducing higher incentives to repay. The latter channel is particularly important for low-income college graduates. Consequently, financing college education became less risky, which increased enrollments. On the other hand, allowing less financially constrained borrowers into the program might also affect the default pattern. This group of borrowers has lower debt on average, since they are eligible for smaller loans than borrowers from low-income families. Studies show that default rates are increasing in education debt levels independent of after-college earnings (Dynarsky (1994), Ionescu (2008), and Lochner and Monge (2008)). Additionally, borrowers from high-income families are associated with better academic preparedness (Cunha et al. (2005)), but poor academic performance has been cited as the number one reason for loan default (Volkwein et al. (1998)). My model argues that the flexibility in repayment was clearly more effective in reducing default rates and encouraging enrollment than the relaxation of eligibility requirements.

Regarding the budget consequences for the government, the government's only role in my framework is to subsidize the student loan program. In the benchmark economy, this supposes financing the cost from defaulted loans computed as the loan amount minus the present value

[43] The first policy applies to borrowers who enter repayment in 1991 and the second policy to borrowers who enter repayment in 1997. Data on default rates are not available before 1988. Also, as mentioned, an important change regarding dischargeability of loans was implemented in 1990 and came into effect in 1994 with a follow-up amendment in 1998. The average CDR for the first period was 20.3 %. The benchmark economy delivers a lower default rate, since it does not account for college dropouts, whereas the CDR does. Separate data for default rates for college graduates versus college dropouts are not available.

of the part recouped through repayment and punishments. In the case of the flexible repayment policy, in addition to the cost from defaulted loans, the government has to finance 1) the cost of the discharged loans under income consolidation, and 2) the cost associated with standard consolidation. The former is computed as the difference between the loan amount and the present value of payment, and the latter comes from subsidizing the difference between the fixed consolidated rate and the variable market interest rate. When eligibility requirements are relaxed, the cost to the government comes from defaulted loans. I compute the total cost to the government in present value terms, given below by:

$$
\begin{aligned}
C_B &= \sum_{i \in DEF_B} \left[d_0^i - PV_{p^i_{def}} \right] \\
C_{Pol1} &= \sum_{i \in DEF_{Pol1}} \left[d_0^i - PV_{p^i_{def}} \right] + \sum_{i \in IC_{Pol1}} \left[d_0^i - PV_{p^i_{ic}} \right] + \sum_{i \in SC_{Pol1}} \left[d_0^i - PV_{p^i_{sc}} \right], \qquad (19) \\
C_{Pol2} &= \sum_{i \in DEF_{Pol2}} \left[d_0^i - PV_{p^i_{def}} \right], \qquad (20)
\end{aligned}
$$

with the first equation for the benchmark economy, the second one for the flexible repayment policy, and the third for relaxation of eligibility. The first term is the cost associated with default, with DEF_B (DEF_{Poli}) being the set of agents who choose default. In the second equation, the second term is the cost associated with income consolidation, with IC_{Pol1} being the set of agents who choose this option. The third term represents the cost associated with standard consolidation, with SC_{Pol1} being the set of agents who choose this option.

My results show that there is no cost to the government under the benchmark economy and in the environment with relaxed eligibility requirements, since everything is paid back in default.[44] In the case of flexible repayments, however, the total government cost is sizable. The estimated total subsidy for each college graduate is \$3700. This translates into a cost of \$700 per agent in the economy (in 1982-1984 dollars), with the cost from income consolidation representing 85 % of this amount. As a result, the flexible repayment policy is more costly to the government, which in turn translates into higher taxes paid by consumers. Thus, people are negatively affected by the policy, regardless of whether they attend college. The next section shows, however, that benefits from the reform are different across education groups.

[44]In fact, the model delivers a negative cost of \$60 per agent for an economy of 10,000 agents (in 1982-1984 dollars). This results from the increase in debt penalty, which in practice covers attorney's and collection fees. The model delivers an average collection of \$2480 per defaulter.

4.3.3 Allocational Consequences by Initial Characteristics

To study the benefits and losses from a flexible repayment policy across different groups of high school graduates, I compare the policy environment to the benchmark case. I measure the utility that makes agents indifferent between the benchmark economy and the policy environments, given by $\mu = \frac{W_{Pol} - W_B}{|W_B|}$. The term W_B represents the aggregate present value of utility under the benchmark case with agents being equally weighted and W_{Pol} represents the aggregate present value of utility in the case where the policy experiment is conducted. Thus, $\mu > 0$ implies that agents are better off relative to the benchmark; otherwise, the reverse is true.[45]

Given that my analysis is a partial equilibrium framework economy, price effects are not considered.[46] Thus, I conduct the analysis to discuss allocational consequences and redistributional effects across different groups of high school graduates, rather than address the aggregate quantitative effects. My results suggest that the flexibility in repayment induces utility gains for high school graduates. The college group is better off, on average, relative to the benchmark, even though life-cycle profiles are lower, on average. The explanation is twofold: 1) people who enrolled in college when flexibility in repayment was not available now have the possibility to lower their payments and, thus can increase consumption; 2) people who did not enroll in college before the policy reform and who choose to enroll when flexibility in repayment is available experience a jump in earnings that more than offsets the increase in loan payments and, thus, induces an increase in consumption. Consequently, this group benefits the most from the reform. Table 4 presents the percent of people who enroll in college by quartiles of initial characteristics when flexibility in repayment is introduced. As under the benchmark, college enrollment increases for upper ability quartiles and from middle quartiles of human capital stocks. Changes in college enrollment rates relative to the benchmark are given in parenthesis. People from bottom quartiles of initial assets benefit more from the reform than those from high quartiles of initial assets ($\mu = 0.02$ for quartile one and $\mu = 0.005$ for quartile 4). Flexibility in repayment induces changes in college enrollment by initial asset quartiles, attracting people from bottom asset quartiles to college. This is because flexibility in repayment reduces the risk associated with college financing. For people with low initial assets, this risk is substantial.

This result has important policy implications: subsidizing repayment rather than relaxing eligibility conditions by the time of college enrollment could make college investment more attractive for people from low-income families. Given the generosity of the student loan program,

[45] I focus on the flexibility of the repayment policy, since relaxing eligibility conditions has negligible effects on allocations and life-time utility.

[46] In addition, given the model complexity, proportional income taxation is computation intensive. A version of this environment with simplifications regarding payment options could accommodate a more complex modeling of tax rules, such as income taxes together with an analysis of tax deductions for student loans. In 1997 a deduction for interest on qualified education loans was introduced, which applies to loan interest payments due and paid after 1997.

Table 4: College Enrollment Quartiles of Initial Characteristics

Characteristic	Q1	Q2	Q3	Q4
Ability	0.05 (+0.05)	5.5 (+5.3)	29.8 (+10.8)	58 (+7.3)
Human capital	14 (+5.5)	26 (+3)	34 (+8)	19.5 (+2.5)
Assets	28.5 (+7.5)	24(+5)	20 (+1.3)	17.5 (+1)

Note: Numbers in parenthesis represent deviations from the benchmark.

funds are readily available. Policies that relax credit constraints during college-going years do not attract more people to college, which is consistent with the literature. In contrast, a policy that diminishes the riskiness of college education might induce more people from low-income families to enroll. An important observation is that, in the current environment, assets are independently drawn. In an environment that accounts for the positive correlation between initial assets and human capital and ability, these effects might be diminished. Further research on this issue may be fruitful.

Flexibility in loan repayment delivers higher life-cycle earnings, on average, for people who choose to not go to college. This is due, however, to higher levels of human capital for the remaining pool that does not attend college. In addition, in an environment where the government cost is supported by taxes, high school graduates who do not enroll in college would be negatively affected by this policy. Also, the positive effect for the college group would be diminished in a world where distortionary taxation is introduced to support government costs.

5 Conclusion

I have constructed a theoretical model calibrated to match key properties of the life-cycle earnings distribution for high school graduates. The model suggests that a combination of ability and initial human capital stock determines the decision to enroll in college, while parental wealth has minimal effects on college enrollment. While a large fraction of college graduates choose to default on student loans, their life-cycle earnings are higher, on average, than for non-defaulters.

I ran experiments to study the quantitative implications of alternative loan policies for college enrollment and default. My results suggest that (i) a change in policy that allows students to lock-in interest rates or to switch repayment plans increases college enrollment significantly, but (ii) relaxed eligibility requirements have little effect on enrollment and default rates. The increase in enrollment under the first policy occurs for the high-ability groups and for the middle human capital groups. This creates changes in life-cycle earnings for high school graduates. The former policy benefits people with low levels of initial assets, whereas the latter policy implies minimal gains for this group. I conclude that a policy that allows for flexibility in repayment is more effective in attracting more people to college and reducing default rates in student loans.

Changes in bankruptcy rules that made student loans nondischargeable under Chapter 13 in the Bankruptcy Code might deter students from declaring bankruptcy, given the more severe consequences of default. In addition, the risk of failing at college and the background characteristics of students influence incentives to invest in human capital. Further research will consider these issues.

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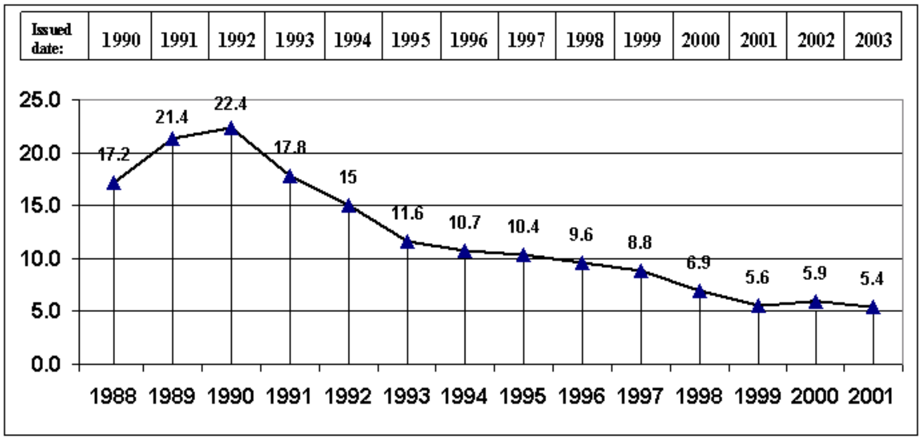
A Appendix

A.1 Data Details

Figure A-1: The Cohort Default Rate



The percentage of borrowers who entered repayment in a fiscal year and defaulted by the end of the next year.
Source: Department of Education

Figure A-2: College Enrollment

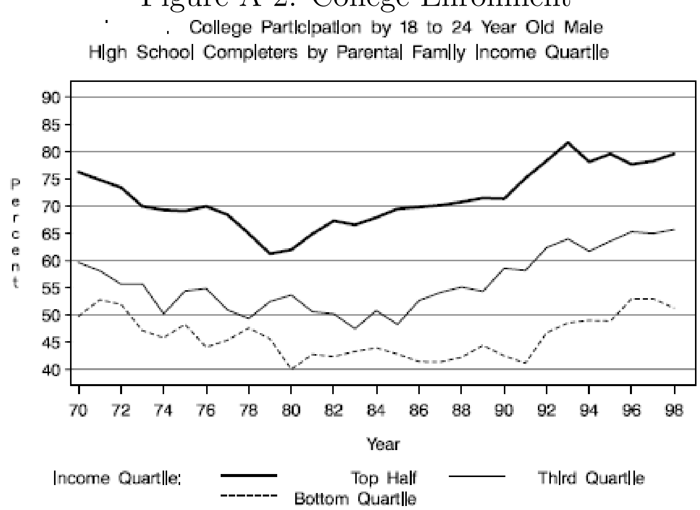
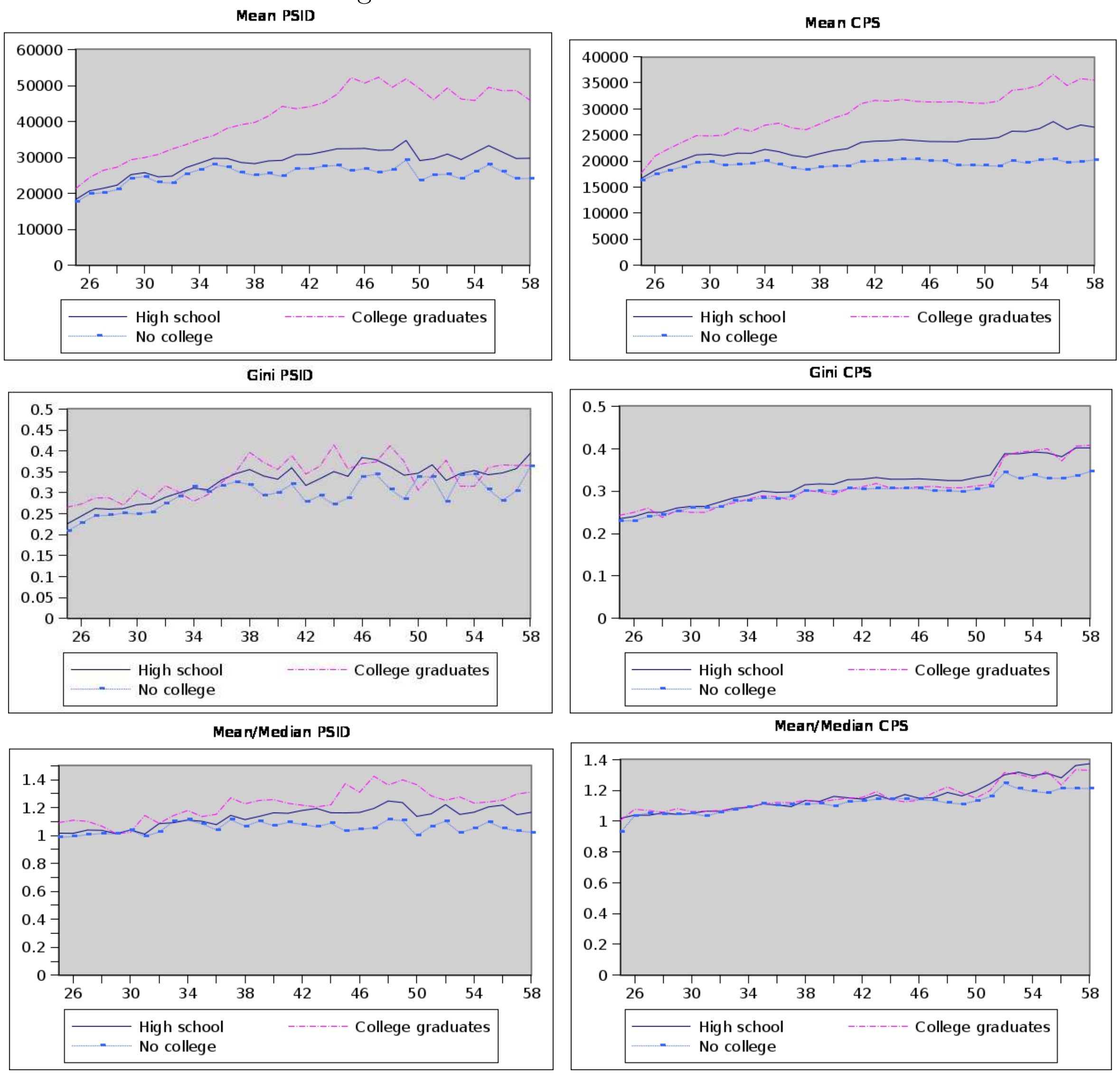


Figure A-3: Data PSID versus CPS



A.2 Computation Procedure

1. I solve for the optimal decision rules for each education choice. For both paths, these include optimal time allocation for human capital/work and savings. On the college path, I additionally solve for optimal borrowing and repaying decisions. To calculate the optimal decision rules, I set a grid on learning ability, initial human capital and initial assets (a, h, x) and compute life-cycle profiles of human capital, hours, and earnings from these grid points.

2. Given the optimal decision rules, I compute the stream of earnings for the two education groups from the model using appropriate parameters values. I also solve for optimal college enrollment for every (a, h, x) combination in the state space.

3. I choose the initial distribution of the state variable to best replicate the properties of U.S. data

documented in Figure A-3. I find the parameter vector, $\gamma = (\mu_a, \sigma_a, \mu_h, \sigma_h, \rho)$, that characterizes the joint initial distribution for high school agents so as to minimize the distance between the model and the data (PSID) statistics for earnings mean, dispersion, and skewness. To recover the joint (a,h) distribution for high school graduates, I use the earnings for the two education groups and the optimal enrollment decision computed in step 2 and the exogenous initial assets distribution.

Computation algorithm:

1. To calculate the optimal decision rules in step 1, for any value of learning ability in the grid $a \in [0, a^*]$, which consists of 20 points, I put a non-uniform grid of 80 points on human capital, $[0, h^*]$, a grid of 15 points on assets, $[0, \overline{x}]$, and a grid of 30 points on debt, $[0, \overline{d}]$; the choices of h^* and a^* may be revised depending on the results of step 3.

a. For the no-college path, I compute the optimal decision rule for human capital and savings at grid points starting from period $j = J-1$, by solving the dynamic programming problem starting from period $J-1$, given $V_J(a,h) = w_J h$. Since the value function is concave in human capital each period, the dynamic programming problem is a concave programming problem. To calculate $h_j(a,h,x)$ at grid points, I compute the value function off grid points using linear interpolation.

b. For the college path, given the complexity of the computation, I break the problem into smaller sub-problems. First, I consider the post-college period, which is divided into two parts: post-payment and payment periods. For the post-payment period, the procedure is similar to that for the no-college path, given the same type of choices. The payment period supposes a more elaborate approach given the enlarged state space, multiple payment options, and stochastic rates. I solve for the optimal decision rule for human capital, $h_j(a,h,x,d,r)$ for each payment case. Backward recursion on Bellman's equations produces h_j for j = 5; ....,I with a different terminal time I for each payment option. Given decision rules for each payment path, I aggregate the results and choose the optimal payment as long as the agent does not choose to change from the standard fluctuating payments status. Once he switches, I consider the rules associated with that particular path; otherwise I continue under the no consolidation status until full payment. Additionally, I keep track of the switching period and the payment choice to ease the computations later on. Given that the last period of payment depends on the chosen payment plan, I dynamically pick the relevant terminal node from the post-payment problem on a case-by-case basis. An additional problem that arises when solving for the payment period after college is the non-concavity of the value function on the no consolidation path, V^{NoC} (Equation 16). This is the maximum over four continuation value functions. Even if these four value functions are strictly concave, the maximum over them is not. This can make the default behavior very sensitive to changes in the state variables, such as debt and human capital. A solution for overcoming the non-concavity problem when there is discrete choice is adding idiosyncratic earnings shocks as implemented in Gomes et al. (2001) and Chatterjee et al. (2007). In my computation, however, there are important differences: 1) I search for the solution over the grid using backward induction on the value function, and 2) Once the switch to another repayment option occurs, the agent cannot switch back. There is no convergence or price iteration involved in my algorithm. I simply use a grid-search solution, and thus in my setup it is sufficient to check that the maximum of the continuation value function is unique during the period of the switch and that the solution is not sensitive to the fineness of the grid. I run a finer grid (100 points on human capital compared to 80 points) and I also check for the uniqueness of the solution. I find that the solution is not sensitive to the choice of the grid and that the maximum is unique.

The last step of part b involves solving for optimal decision rules during college periods. This implies optimal time allocation and savings. Additionally, in the first period, I solve for the optimal borrowing decision. I take the first period value function from the post-college problem as a terminal node for the college periods and solve using backward induction. After endogenizing the borrowing decision, I get the optimal decision rules for the initial state vector (a, h, x).

Solving this problem requires a tremendous amount of time. First, given the state space, I face the so-called "curse of dimensionality" (the grid consists of a total of 1,440,000 points). To avoid this problem, I solve for each level of ability separately. This is possible given that learning ability remains fixed over the agent's life. Second, the evolution of both debt and human capital are intrinsically determined by stochastic rates and optimal payment and time allocation decisions the agent makes. This imposes double interpolation with respect to debt and human capital, which can take a huge amount of time. To optimize on this, I implement the multi-linear interpolation method as described by John Rust (Amman et al. (1996)). I use simple piecewise linear interpolation of the value function in each coordinate of the state vector. To carry out the procedure, I impose an underlying grid on the state space defined by a Cartesian product of unidimensional grids over each coordinate of the state vector. I estimate the value function at an arbitrary point in the state space as a linear combination of the values of the function at the vertices of the grid hypercube containing the arbitrary point. This allows me to carry out the double interpolation procedure in a fraction of the time needed using the Matlab function. Third, after solving for optimal rules, I use the optimal borrowing choice to restrict my attention to the necessary data. I ignore the irrelevant debt levels and the subsequent choices to economize on stored data. I aggregate data for all ability levels and store the decision rules for the initial state space vector, given the determined payment choices and switching periods. Overall, these improvements reduced the computation time by 70%.

2. In step 2, I use the grid of 20 points on the ability grid, $[0, a^*]$, 15 points on the asset grid, $[0, \overline{x}]$, and extract 20 points out of the 80 points on the human capital grid, $[0, h^*]$.[47] This implies

[47]Solving for decision rules requires a sufficiently fine grid for human capital, whereas finding the distribution

a total of 6000 points (a, h, x). Using the decision rules from step 1, I simulate life-cycle profiles of labor earnings from any initial pair (a, h, x) for each education choice and I solve for the optimal enrollment decision.

3. In step 3, I use the Matlab function "fminsearch", which implements the simplex algorithm to find the 400 values of the histogram over $[0, a^*] \times [0, h^*]$ that minimizes the distance between model and data statistics. For any trial of the vector describing the initial distribution, I calculate the mean, dispersion and skewness statistics at each age using the calculated life-cycle profiles and the guessed initial distribution. If the histogram that best matches the data puts strictly positive weight on (a,h) pairs where $a = a^*$ and $h = h^*$, then the upper bounds are increased and steps 1-3 are repeated.

A.3 Institutional Details on Ben-Porath: Implications for Initial Distribution

To study the significance of college enrollment and institutional details for the initial distribution, I compare the characteristics of the joint distribution of learning ability and initial human capital stock within my model to those derived within the standard Ben-Porath framework. I redo the calibration of the joint initial distribution within Ben-Porath in Huggett et al. (2006) restricted to high school graduates in my PSID sample.[48] Table A-1 presents the findings for both models. Note that lower levels of human capital and higher levels of ability, on average, are needed to match life-cycle earnings of high school graduates within my framework relative to Ben-Porath. This is because optimal accumulation within the standard model dictates that, early in the life-cycle, agents with high learning ability devote most or all of their time to accumulating human capital (see Huggett et al. (2006) for details). My version allows for more productive human capital accumulation in college. The ability to learn significantly contributes to human capital production in this period. Consequently, lower initial human capital levels and higher ability levels match life-cycle earnings and the correlation between human capital and learning ability is lower when college enrollment is endogenized.

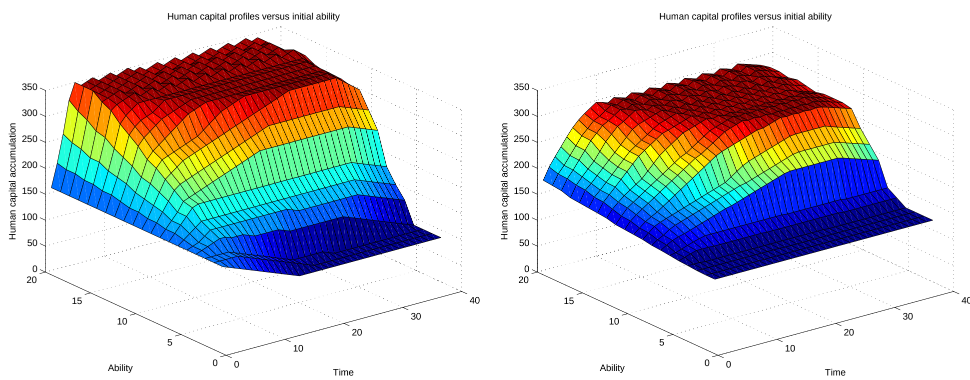
of initial characteristics does not (for detailes see Huggett et al. (2006)).

[48] I use the PSID sample for this comparison, since data statistics are closer to the ones in Huggett et al. (2006).

Table A-1: Joint Distribution of Ability and Human Capital for High School Graduates

Characteristic	Statistic	My Model	BP Model
Ability	Mean(a)	0.301	0.259
	Coef of Variation (a)	0.517	0.456
	Skewness(a)	1.687	1.464
Human capital	Mean(h)	74.691	91.7
	Coef of Variation (h)	0.527	0.475
	Skewness(h)	1.729	1.53
	Correlation (a,h)	0.769	0.852

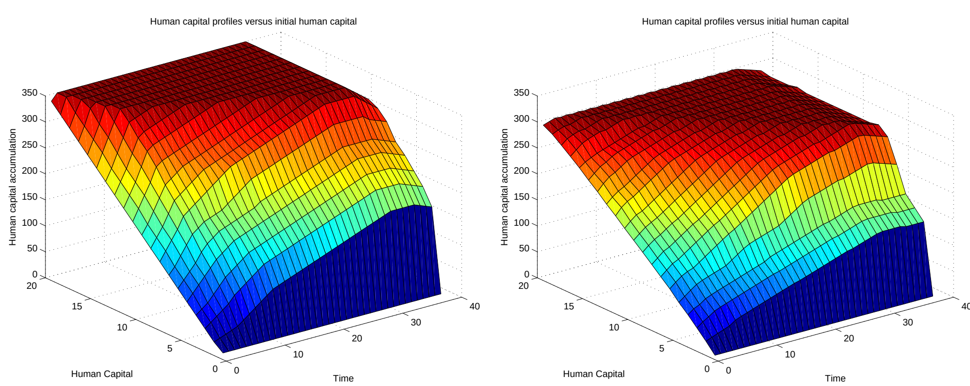
Figure A-4: Human Capital Accumulation By Education Group



(a) College (b) No college

Note: Figures are drawn across ability levels (with low to high levels from 0 to 20), for a fixed level of initial human capital and assets.

Figure A-5: Human Capital Accumulation By Education Group



(a) College (b) No college

Note: Figures are drawn across initial human capital levels (with low to high levels from 0 to 20), for a fixed level of ability and initial assets.