Education, Credit Constraints and Default Incentives*

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Abstract

1 Introduction

In the 2000-01 academic year, over 9 million American college students borrowed a total of more than $38 billion from federal student loan programs to help finance their education (The College Board [5]). Should the government be providing more credit? If so, should all students be offered more credit? What would happen to student loan default rates if the government raised borrowing limits? To answer these questions, a better understanding of the student loan market is needed. This paper aims to provide that understanding.

Previous models of human capital and credit constraints have assumed that credit limits are fixed and independent of the observable characteristics and decisions of individuals (e.g. Aiyagari, Greenwood, and Seshadri [1], Caucutt and Kumar [11], Hanushek, Yilmaz, and Leung, [12], and Keane and Wolpin [13]).[1] In this work, credit constraints severely restrict the amount of human capital investment undertaken by students from poorer families. As we show below, the nature of borrowing constraints in these models also implies that investments in human capital should be *decreasing* in

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[1] Alternatively, credit 'constraints' are sometimes represented by interest rates that increase with the amount borrowed or that exogenously vary in the population (e.g. Becker [3], Cameron and Taber [8] and Card [9]).

ability among constrained borrowers (for reasonable intertemporal elasticities of substitution). This is clearly counterfactual.

A more serious inspection of the federal student loan system (e.g. the Perkins, William D. Ford Federal Direct Student Loan (FDSL), and Federal Family Education Loan (FFEL) programs) suggests additional features of the lending environment that have been neglected in previous work. In particular, student loan amounts are not only constrained by an upper limit on borrowing, but they are also constrained by expenditures on schooling. Individuals choosing to spend little on their schooling cannot borrow large sums to finance consumption. By linking loan limits to investments in human capital, the government student loan system encourages investment among constrained borrowers. As a result, schooling expenditures do not necessarily lower students' consumption levels below what they would be if they did not attend school (or if they were to attend less costly institutions). This implies that investments in human capital are likely to be efficient even among many constrained borrowers. Furthermore, investment is never decreasing in ability. Incorporating the additional feature of the student loan system that links borrowing limits to investment in human capital not only adds realism to our model, but it also produces more credible predictions about investment.

We next consider the potential for default, an important concern given that one-in-twenty recent student borrowers have defaulted on their loans within two years of leaving school (down dramatically from one-in-five in the early 1990s). Although re-payment amounts for student loans are not explicitly contingent on post-school earnings, they effectively are through the decision to default or re-pay. Of course, those who default are subject to various punishments imposed by lenders or the government. We examine the role played by the option of default and the associated punishments in determining human capital investment decisions. Introducing this feature of the system yields additional insights that have not been studied before. For example, we find that default will tend to occur among the least able, and that it will encourage over-investment in human capital among those most likely to default. Using data from the Baccalaureate and Beyond Surveys, we empirically examine a number of cross-sectional predictions for default, including the relationship between college major, post-school earnings, educational debt, and the probability of default.

Based on previous models of credit constraints and schooling, two empirical strategies have been employed to test for credit constraints in the market for human capital. One strategy examines whether individuals from different family income levels have different college enrollment rates conditional on ability and other variables that may influence tastes for schooling or the ability to attend. The second strategy compares the returns to schooling for individuals who are expected to face different interest rates or constraints on their borrowing. (See Carniero and Heckman [10] for a recent synthesis of this research.)

Our model of the government student loan system suggests that caution should be used in inter-

preting the results of these strategies. For a wide range of abilities, our results indicate that schooling decisions are independent of initial assets (or family income) among constrained borrowers. As a result, these tests are unlikely to prove or disprove the existence of credit constraints or the extent to which credit constraints bind. Instead, they may be (more narrowly) used to infer the degree to which credit constraints restrict investments in human capital. A better test for credit constraint would focus on changes in consumption as students leave school; however, practical issues make this difficult.

We explore a number of potential shortcomings of the current lending system. For example, the current system encourages less able individuals and those choosing careers with low earnings potential to over-invest and default on their loans while it may limit the borrowing and investments of more able individuals choosing high paying careers. Given the system's apparent weaknesses, it is important to ask whether (and how) it might be improved. In answering this question, we build on our earlier paper, Lochner and Monge [16], and the work by Alvarez and Jermann [2], Kehoe and Levine [14], and Kocherlakota, [15] to determine an optimal student lending system with uncontingent loans and limited enforcement. We first discuss how optimal loan limits and interest rates should vary across different students, taking current punishment and enforcement strategies as given. The implied borrowing, investment, and default decisions can be compared with those of the current system, as can changes in social welfare. Finally, we discuss the effects of changes in the punishments faced by defaulting borrowers on the optimal environment, focusing on changes in borrowing, investment, default, and social welfare.

The paper proceeds as follows. Section 2 summarizes major features of the U.S. federal student lending system. We then develop a model of human capital investment, student lending, and default in Section 3 that reflects important features of this system. In Section 4, data from the Baccalaureate and Beyond Surveys are used to empirically examine theoretical predictions for student borrowing and default patterns. Section 5 develops a more efficient lending system and explores it's predicted patterns for human capital investment and default. Section 6 concludes.

2 Student Lending

2.1 Federal Student Loan Programs

From the 1990-91 academic year to that of 2000-01, federal aid in the form of student loans increased by 136% and the percent of total federal student aid provided through government loans rose from 49 to 58 percent. By any measure, federal student loans are an important source of financing for higher education. Most of these loans are provided through the Stafford Loan program, which awarded about $33 billion in the 2001-02 academic year compared to just over $4 billion awarded through Parent Loans for Undergraduate Students (PLUS) and $1 billion through the Perkins Loan program. Total Pell Grant awards amounted to about $8 billion (The College Board [5]). In this section, we

briefly discuss important features of the main federal student loan programs as summarized in Table 1.

Stafford and PLUS Loans

Historically, private lenders have provided the capital to student borrowers (and their parents) with the government guaranteeing those loans with a promise to cover any unpaid amounts under the Stafford and PLUS programs. This arrangement is now referred to as the Federal Family Education Loan Program (FFEL). Since the 1994-95 academic year, the federal government has begun to directly provide these loans through the William D. Ford Federal Direct Student Loan (FDSL) program. Regardless of the source of funds, the rules governing these two institutions are the same. Both offer subsidized and unsubsidized Stafford Loans as well as PLUS loans.[2] While Stafford loans are disbursed to students, PLUS loans are given to parents.

The distinction between subsidized and unsubsidized Stafford loans hinges on the treatment of interest on loans while students are enrolled. Students are not charged interest on subsidized loans as long as they are enrolled in school (the government pays the interest), while interest accrues on unsubsidized loans. In order to qualify for subsidized loans, students must demonstrate financial need, which depends on family income, dependency status, and the cost of the institution attended. Unsubsidized loans may be obtained without demonstrating need. In general, students under age 24 are assumed to be dependent, in which case their parents' income is an important determinant of their financial need.

Dependency status and class level determine the total amount of Stafford loans a student is eligible for as seen in Table 1. Dependent students can borrow as much as $23,000 over their undergraduate years, while independent students can borrow twice that amount.[3] Annual limits are lowest for the first year of college, increasing in the following two years.

Interest rates on Stafford loans are variable (currently 2.3% above the 91 day Treasury bill bond, though this has varied slightly over time) subject to an upper limit of 8.25%. Fees can also be levied on borrowers of up to 4%, which is proportionally subtracted from each disbursement. Students need not re-pay their loans while enrolled at least half-time, though interest does accrue on unsubsidized loans. After finishing (or leaving) school, borrowers are given a 6 month grace period before they are required to begin re-paying their Stafford loans.

The PLUS program allows parents who do not have an adverse credit rating to borrow for their dependent children's education. Generally, parents can borrow up to the total cost of schooling less any other financial aid given to the student. For this purpose, the cost of schooling includes tuition and

[2]Prior to the introduction of unsubsidized Stafford Loans in the early 1990s, Supplemental Loans to Students (SLS) were an alternative source of unsubsidized federal loans for independent students.

[3]Dependent students whose parents do not qualify for the PLUS program can borrow up to the independent student Stafford loan limits. Prior to 1992-93, Stafford loan limits were lower than current levels. Dependent undergraduate students could borrow up to a cumulative total of $17,250, while independent undergraduates could borrow up to $37,250.

Table 1: Summary of Current Federal Loan Programs

	Stafford		Perkins	PLUS
	Dependent Students	Independent Students*		
Recipient	Students	Students	Students	Parents
Eligibility	Subsidized: Financial Need** Unsubsidized: All Students		Financial Need	No Adverse Credit History Dependent Students
Undergraduate Limits:				
Year 1	$2,625	$6,625	$4,000	All Need
Year 2	$3,500	$7,500	$4,000	All Need
Years 3+	$4,000	$8,000	$4,000	All Need
Cum. Total	$23,000	$46,000	$20,000	All Need
Graduate Limits:				
Annual	$18,500		$6,000	N/A
Cum. Total***	$138,500		$40,000	N/A
Interest Rate	Variable, 8.25% Limit		5%	Variable, 9% Limit
Fees	Up to 4%		None	Up to 4%
Grace Period	6 Months		9 Months	None

Notes:
* Students whose parents do not qualify for PLUS loans can borrow up to independent student limits from Stafford program.
** Subsidized Stafford loan amounts can be no greater than the borrowing limits for dependent students; independent students can also borrow unsubsidized Stafford loans provided that their total (subsidized and subsidized) loan amount is not greater than the independent student limits.
*** Cumulative graduate loan limits include loans from undergraduate loans.

fees, reasonable room and board allowances, expenses for books, supplies, transportation, loan fees, and an allowance for computers.[4] Interest rates are variable (slightly higher than those on Stafford loans) subject to a 9% limit, and fees can be assessed up to 4% of loan amounts. Parents must begin re-paying loans within 60 days of the final disbursement for the corresponding enrollment period – there is no grace period.

Perkins Loans

The Perkins Loan program targets students in need, distributing funds provided by the government and post-secondary institutions. Loan amounts depend on the student's level of need and funding by the school attended, but they are subject to an upper limit of $4,000 per year for undergraduates and $6,000 per year for graduate students. By far the most financially attractive loan alternative for students, Perkins loans entail no fees and a fixed low interest rate of 5%. (See Table 1.) Students are also given a 9 month grace period after finishing (leaving) school before they must begin re-payment of a Perkins loan.

Re-payment and Default

Given recent trends, one in twenty of student borrowers will default on their federal student loans within the first two years of re-payment. Overall, the total amount outstanding from defaulted student loans stands at $25 billion (US Dept. of Education [17]). While default rates have declined considerably since reaching their peak of 22% in 1990, they are still quite high and entail substantial sums of money. Given the frequency of default and the monetary sums involved, it is worth considering the process of re-payment and the punishments imposed on borrowers that choose to default.

Re-payment of student loans begins six (Stafford) or nine (Perkins) months after finishing school. Borrowers that are having difficulties making payments and that can establish financial hardship may qualify for either a forbearance or deferment, which will temporarily delay payments.[5] Loans covered by the federal system cannot generally be expunged through bankruptcy except in very special circumstances. Thus, the only way a borrower can 'avoid' re-payment when he does not qualify for a deferment or forbearance is to simply stop making payments, or default. A borrower is considered to be in default once he becomes 270 days late in making a payment. If the loan is not fully re-paid immediately, or if a suitable re-payment plan is not agreed upon with the lender, the default status will be reported to credit bureaus, and collection costs (up to 25% of the balance due) may be added to the amount outstanding. Up to 10% of the borrower's wages can be garnished (15% can be garnished by the Department of Education if it becomes involved in the collection process), and federal tax refunds

[4] Room and board allowances are not given for students attending less than half-time.
[5] Interest continues to accrue during a forbearance, but it does not during a deferment.

can be seized and applied toward the balance.[6] In practice, these sanctions are sometimes limited by the inability of institutions to locate those who have defaulted. Wage garnishments are ineffective against defaulting borrowers that are self-employed. Furthermore, individuals can object to the wage garnishment if it would leave them with a weekly-take home pay of less than 30 times the federal minimum wage, or if the garnishment would otherwise result in an extreme financial hardship.

2.2 Nongovernment Student Loans

2.3 Grants and Scholarships

3 The Nature of Borrowing Constraints

It is convenient to begin with the standard model of human capital formation. Consider two-period lived individuals who must choose their investment in human capital during the first period and consumption in both periods. Agents are endowed with initial assets a. In the second period, they receive wage income w which is increasing in investment, y, and ability, e. In particular, $w(e, y) = ey^{\alpha}$. In this economy, individuals choose investment, y, and borrowing, d, to

$$\max_{y,d}\{u(a + d - y) + \beta u(w(e, y) - Rd)\}, \tag{1}$$

where $u(\cdot)$ is an (increasing, concave) utility function and $\beta > 0$ is a time discount factor. The (gross) interest rate $R \geq 1$ is given.

Without constraints on borrowing, individuals simply invest in their human capital to maximize lifetime earnings (net of investment costs) and borrow (or save) to optimally smooth consumption. Optimal unconstrained investment in human capital is, therefore, given by

$$y^u(e) = \left(\alpha e R^{-1}\right)^{1/(1-\alpha)}.$$

Clearly, investment is increasing (and convex) in ability, e, and independent of initial assets, a. For $R = \beta^{-1}$, individuals will equate consumption over time and optimal first period borrowing will be

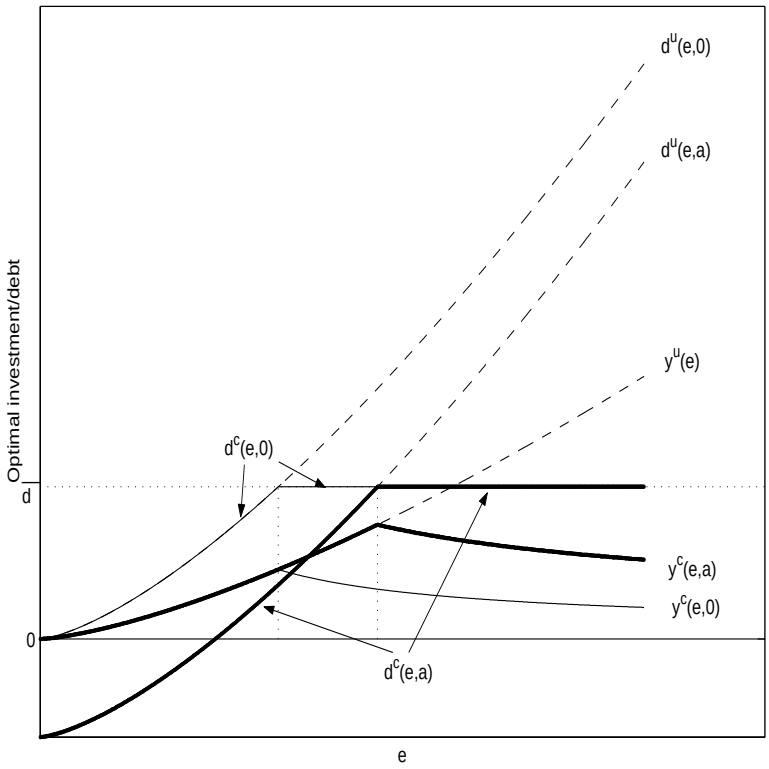
$$d^u(e, a) = \frac{e^{1/(1-\alpha)}(\alpha R^{-1})^{\alpha/(1-\alpha)}(1 + \alpha R^{-1}) - a}{1 + R}.$$

Like investment, borrowing is increasing and convex in ability, e; however, borrowing is decreasing in initial assets, a.[7] Optimal unconstrained borrowing, $d^u(e, a)$, and investment, $y^u(e)$, are gaphed in Figure 1 for two different initial asset levels (zero and $a > 0$) as a function of ability when the intertemporal elasticity of substitution is less than one.

[6] Other sanctions against borrowers who default include a possible hold on college transcripts, ineligibility for further federal student loans, and ineligibility for a deferment or forbearance. Since the early 1990s, the government has also begun to punish educational institutions with high student default rates by making their students ineligible to borrow from federal lending programs.

[7] For $\beta \neq R^{-1}$, borrowing will also depend on the shape of the utility function.

Figure 1: Optimal Investment and Borrowing for Unconstrained and Constrained Cases



Since human capital cannot serve as collateral for financial debts, Becker [4] noted that individuals may be constrained in their ability to borrow for schooling. The literature on schooling has typically taken this into account by assuming that individuals face an upper limit, $\bar{d}$, on the amount they can borrow for school (e.g. Aiyagari, Greenwood, and Seshadri [1], Caucutt and Kumar [11], Hanushek, Yilmaz, and Leung, [12], and Keane and Wolpin [13]). This credit limit is generally independent of individual characteristics and investment decisions (as well as government policy).[8] In this case, borrowing limits constrain individual borrowing decisions such that

$$d \leq \bar{d}.$$

Borrowers with high enough initial assets or low enough ability will remain unconstrained provided $d^u(e,a) \leq \bar{d}$. However, individuals who wish to borrow more than $\bar{d}$ will be adversely affected by the borrowing constraint. They choose investment to solve the following first order condition:

$$u'[a + \bar{d} - y] = \beta e \alpha y^{\alpha-1} u'[ey^{\alpha} - R\bar{d}].$$

Optimal constrained investment $y^c(e,a)$ will be less than unconstrained investment levels, $y^u(e)$, and will depend on initial assets, a. See Figure 1 for a comparison of constrained investment and borrowing

[8] Alternatively, some authors have modelled credit constraints by assuming that interest rates vary exogenously across persons or increase in the amount borrowed (e.g. Becker [4], Cameron and Taber [8], Card [9]).

functions $y^c(e,a)$ and $d^c(e,a)$ with their unconstrained counterparts. Two sets of investment and borrowing functions are shown: one for individuals with zero (or negligible) initial assets and another for those with $a > 0$.

When individuals are borrowing constrained, each additional dollar of investment must come out of current consumption, which becomes more and more costly in utility terms. Because of this, comparing individuals with different abilities can yield a surprising prediction: investment may be declining in ability among constrained borrowers. To see why, consider that a change in ability acts much like a change in the price of second period consumption for constrained borrowers. An increase in ability, therefore, entails both *income* and *substitution* effects. The substitution effect encourages investment by increasing the return per unit of investment. A higher ability makes future consumption cheaper relative to current consumption, causing individuals to substitute current with future consumption by increasing investment. On the other hand, income effects discourage investment among higher ability individuals when consumption is a normal good. Higher ability implies a higher net present value of wealth for any level of investment. As a result, more able individuals want to increase both current and future consumption. Holding investment constant would increase future consumption in response to an increase in ability, but constrained agents can only increase current consumption by reducing investment. The net effect of ability on investment, therefore, depends on the balance of offsetting income and substitution effects.

With linear utility, there would be no income effects, in which case investment would unambiguously increase with ability among constrained borrowers (i.e. the case discussed by Becker [4]). More generally, if the intertemporal elasticity of substitution for consumption (IES) is less than one, as most empirical studies indicate (see Browning, Hansen, and Heckman [6]), then investment should be *decreasing* in ability among constrained borrowers as shown in Figure 1. This result is clearly counterfactual (e.g. Cameron and Heckman [7]). See Table 1...

The standard model assumes that borrowing limits are uniform across agents and invariant to their ability and human capital investment choices. However, one might reasonably expect that more able individuals or those investing more in their human capital can be counted on to repay their loans more reliably. As such, rational lenders should respond by offering more credit to those individuals. In fact, the government student loan system explicitly takes investment decisions into account when disbursing loans. As we show next, incorporating this feature of the government student loan system not only provides a more realistic structure for understanding human capital investment decisions; it also eliminates the counterfactual prediction that investment should be declining in ability among constrained borrowers.

3.1 The Government Student Loan (GSL) System

As described earlier in Section 2, federal student loans are limited in two ways: (i) they are constrained by government set upper limits on borrowing as in Table 1) and (ii) they cannot exceed total schooling expenditures.[9] The second constraint on borrowers is not accounted for in traditional models with borrowing constraints; yet, this feature generates new and interesting investment behavior that conflicts with conventional thinking about borrowing constraints and the efficiency of investment.[10]. In the current student loan market, effective constraints are given by $d \leq min\{y, \bar{d}\}$ and not just $d \leq \bar{d}$ as is commonly assumed. The distinction is economically important.

Consider individuals with relatively low initial assets for whom $d^u(e,a) \in (y^u(e), \bar{d})$ or, equivalently, those with ability $e \in (\bar{e}_1(a), \bar{e}_2(a))$. These individuals are constrained from borrowing as much as they would like, since that amount exceeds their desired investment in human capital. They would like to borrow above and beyond the cost of schooling, but they are not constrained by the upper limit on borrowing, $\bar{d}$. (As such, they would not be treated as constrained in the standard framework.) Additionally, individuals with a slightly higher ability, $e \in (\bar{e}_2(a), \bar{e}_3)$, would typically be constrained by $\bar{d}$; however, under the GSL program, the constraint $d \leq y$ is still more restrictive.[11] These individuals would be constrained under the standard model and under the government student loan system, only the constraint that binds differs. In both cases (i.e. $e < \bar{e}_3$), these individuals maximize lifetime utility (equation 1) subject to $d = y$. Perhaps surprisingly, this problem yields optimal investment equal to $y^u(e)$. That is, despite the fact that these individuals are constrained from borrowing as much as they would like, they invest the unconstrained optimal amount in their human capital. This is because increases in investment are accompanied by one-for-one increases in borrowing limits when $y \leq \bar{d}$. Thus, increases in investment do not require reductions in consumption while in school. Adding on the second constraint ($d \leq y$) to the first ($d \leq \bar{d}$), we observe that additional less able persons will become constrained in the latter case; however, more ability types will invest the unconstrained efficient amount (in particular, the least able of those who were already constrained). The relationship between investment ($y^g(e,a)$), borrowing ($d^g(e,a)$), and ability under this lending scheme is shown in

[9] Student loan amounts do not explicitly cover foregone earnings, however, typical allowances for 'living expenses' are quantitatively similar to the foregone earnings of spending most of one's time on school for nine months of the year.

[10] A slightly more complicated and realistic model of the federal student loan system would incorporate allowances for living expenses and would allow maximum borrowing limits to depend negatively on initial assets (e.g. qualification for the Perkins loan requires proof of financial need). Letting L represent living expenses, $f(a)$ the implicit 'tax' on initial assets used in calculating financial need, and $\bar{d}(a)$ the upper borrowing limit conditional on initial assets, the effective borrowing constraint in this case can be written as $d \leq \min\{L + y - f(a), \bar{d}(a)\}$. This problem yields investment equal to $y^u(e)$ for individuals with $y^u(e) < \bar{d}(a) + f(a) - L$ (i.e. those unconstrained by $\bar{d}(a)$) and equal to $\bar{d}(a)$ for those constrained by the upper limit on borrowing. The basic patterns are the same as those of the more simple model, except the cutoff point at which investment no longer equals the unconstrained optimal amount depends on the amount of living expenses allowed for by the program and the amount of initial assets of an individual. Additionally, the amount of investment among individuals constrained by the upper borrowing limit will depend on their initial assets.

[11] Mathematically, $\bar{e}_1(a) = \left[\frac{a}{(\alpha R^{-1})^{\frac{\alpha}{1-\alpha}} - R(\alpha R^{-1})^{\frac{1}{1-\alpha}}}\right]^{1-\alpha}$, $\bar{e}_2(a) = \left[\frac{a+(1+R)\bar{d}}{(\alpha R^{-1})^{\frac{\alpha}{1-\alpha}} + (\alpha R^{-1})^{\frac{1}{1-\alpha}}}\right]^{1-\alpha}$, and $\bar{e}_3 = \frac{R\bar{d}^{1-\alpha}}{\alpha}$.

Figure 2: Optimal Investment and Borrowing with GSL (for $a > 0$)

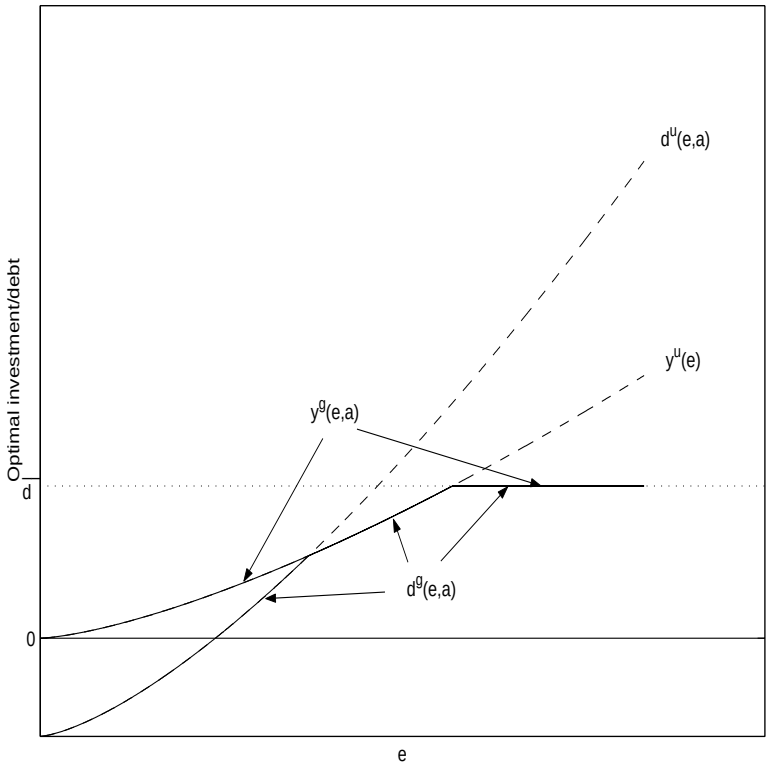


Figure 2 for individuals with two levels of initial assets (zero and $a > 0$). Comparing these investment profiles with those of Figure 1 for borrowers only facing an upper limit on borrowing, $\bar{d}$, we observe that investment is higher (and equal to the unconstrained optimal amount) for middle ability types when the additional government borrowing constraint is imposed.

Poor but smart individuals (i.e. low a and $e \geq \bar{e}_3$) will be constrained by the upper limit on borrowing, $\bar{d}$, rather than the constraint $d \leq y$. These individuals would need to reduce their consumption while in school to fund their optimal investment amount. As a result, their problem is more similar to that of the standard constraint case; however, it is not identical. If the intertemporal elasticity of substitution for consumption is less than one, an assumption we will make throughout the rest of this paper, these borrowers will choose to invest $\bar{d}$. While poor individuals with ability above $\bar{e}$ would prefer to invest less than $\bar{d}$ (recall that investment is declining in ability for constrained borrowers in the standard framework), the fact that borrowing cannot exceed investment effectively rules this out. Thus, given some level of initial assets, investment will be increasing in ability until $\bar{e}$, after which point it remains at $\bar{d}$. Investment never declines in ability under the government lending system as we see in Figure 2.

The fact that investment among individuals constrained from borrowing more than their investment but not by the upper limit does not differ from investment among unconstrained persons does not

mean that they are as well off as they would be if they could borrow freely. These individuals face extremely distorted consumption profiles, consuming much less than the optimal amount while they are in school. While the additional constraint that $d \leq y$ appears to improve investment behavior for many ability types, it actually makes these individuals worse off – they would prefer to invest less than the amount they borrow but are restricted from doing so.

The fact that investment does not depend on initial assets for individuals with ability $e \leq \bar{e}_3$ has important implications for the recent empirical tests of borrowing constraints among college students (e.g. see Carniero and Heckman [10]). These tests have tended to compare college enrollment or attendance rates for high and low income families or have looked for differential marginal rates of return to schooling across individuals from different backgrounds. But, the structure of the federal student loan system suggests that investment may not differ by family income or wealth across a wide range of abilities even though many poorer students may be constrained. The fact that many of these studies find little difference in enrollment rates or rates of return by family income is consistent with a government lending system with relatively high upper limits on borrowing. ADD SOMETHING ABOUT LOAN LIMITS FROM TABLE 1. Still, many students may be constrained from borrowing what they would like to finance consumption while in college. While there are no empirical studies that we know of that examine this prediction, it does not seem unlikely.[12]

Borrowing with the Option of Default

Lending to students is constrained for an obvious reason: there is no guarantee that students will repay their debt once they leave school. In fact, student loan default rates have been as high as 22% in the United States (1990 was the peak year for default); although, they have declined considerably since then. Incorporating the opportunity to default adds further wrinkles to the human capital investment problem that have not, yet, been studied.

As described in Section 2, default on federal student loans entails a variety of potential punishments. Among the more important is the potential for wage garnishment. To model this, we assume that individuals that choose to default on their loans face a wage garnishment rate of γ on their earnings. Because former borrowers who earn very low incomes are typically not subject to any punishment by the government, we further assume that individuals earning less than $\underline{w}$ are released from their loan obligations without punishment. Altogether, we assume that the punishment for non-payment is given by $max\{\gamma(w(e,y) - \underline{w}), 0\}$ and will refer to anyone not re-paying their loan as defaulters, despite the fact that individuals with very low earnings are not officially considered in default.

For borrowers, the decision to default simply involves comparing the cost of re-payment, Rd, with

[12]This is a difficult prediction to test, since many college students live at home part time and receive inter vivos financial and in-kind transfers while in school. This makes it difficult to accurately measure consumption among college students.

the cost of default. Effective re-payment is, therefore,

$$P(e, y, d) = min\{Rd, max\{\gamma(ey^{\alpha} - \underline{w}), 0\}\}.$$

Incorporating this into the first period decision problem produces the following investment and borrowing decision:

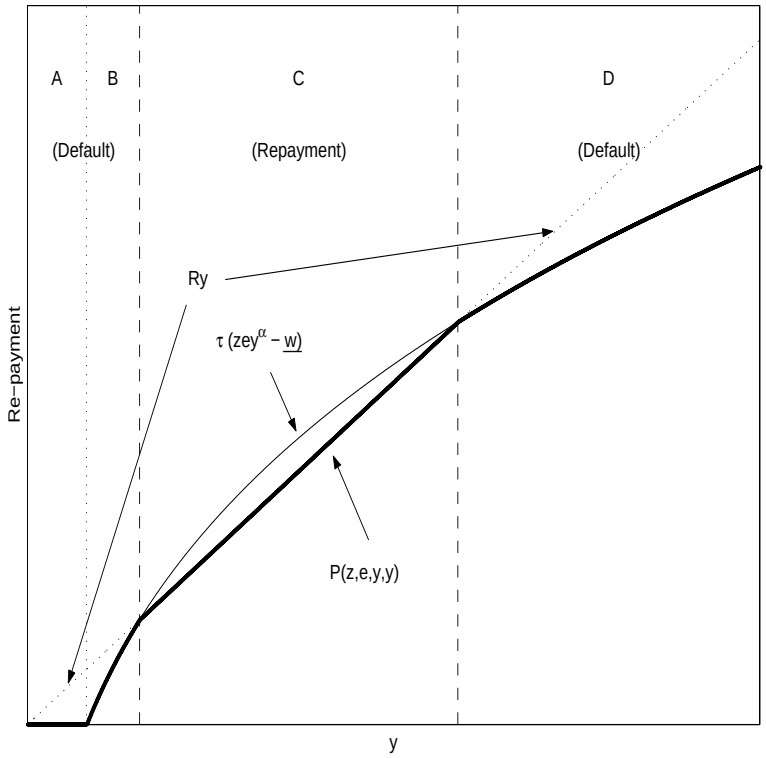
$$\max_{y,d}\{u(a + d - y) + \beta u(w(e, y) - P(e, y, d))\} \qquad \text{subject to } d \leq min\{y, \bar{d}\}.$$

Among poor persons constrained by $d = y$, re-payment is given by $P(e, y, y) = min\{Ry, max\{\gamma(ey^{\alpha} - \underline{w}), 0\}\}$. For large $\bar{d}$, Figure 3 graphically represents a re-payment schedule for poor individuals as a function of y (assuming $d = y$) given e. Notice that effective re-payment (dark solid line) is the lower envelope of the default (light solid line) and no-default (dotted line) payment schedules. Interestingly, default occurs at the extremes – regions A, B, and D. Because of the limit on garnishments for earnings below $\underline{w}$, individuals with low investment and debt (regions A and B) are able to keep all, or at least most, of their earnings when they default. Thus, they are better off defaulting than re-paying their loans. Due to diminishing marginal returns to investment, the re-payment obligations of individuals with very high levels of investment/debt (region D) exceed the garnishments they face, and they, too, are also better off defaulting. Only individuals with mid-level investment and earnings (region C) find it in their best interest to re-pay their loans.

If $\underline{w}$ were reduced to zero (and if γ is sufficiently large), there would be no default among those investing very little as the re-payment curve in Figure 3 would shift leftward to the origin. At the other extreme, $\underline{w}$ may be high enough or γ low enough so that the middle region of re-payment completely disappears. In this case, everyone would choose to default regardless of his debt and investment.

The option of default introduces a fundamental non-convexity to the investment decision problem. Individuals will choose to either re-pay their loan and invest the constrained optimal amount $y^g(e, a)$ described above, or they will invest and borrow the maximum $y = \bar{d}$ and default on their loans. If individuals intend to re-pay their loans, they face the same decision problem as the no-default case described above. But, if they intend to default, it is optimal to borrow and invest the maximum $\bar{d}$ and default, since the marginal cost of borrowing and investing more when choosing to default is always less than the marginal benefit of investing another dollar. For example, compare the marginal cost of investment based on the optimal re-payment schedule ($\frac{\partial P}{\partial y}$) with the marginal return to investment ($\alpha e y^{\alpha-1}$) for constrained borrowers. In the case underlying Figure 3, the marginal cost of investment is zero in region A, $\gamma\alpha e y^{\alpha-1}$ in regions B and D, and R in region C. As long as $\gamma < 1$ the marginal return to investment is strictly greater than the marginal cost throughout regions A, B, and D. Thus, individuals will never choose to invest in regions A or B, and investments in region D will be at (or above) the maximum allowable amount, $\bar{d}$. Investments in region C will equate the marginal return to

Figure 3: Re-payment as a function of y given e when default occurs at extremes



the gross interest rate, yielding the unconstrained optimal amount of investment, $y^u(e)$. More simply, investment will either equal $y^u(e)$ or $\bar{d}$.

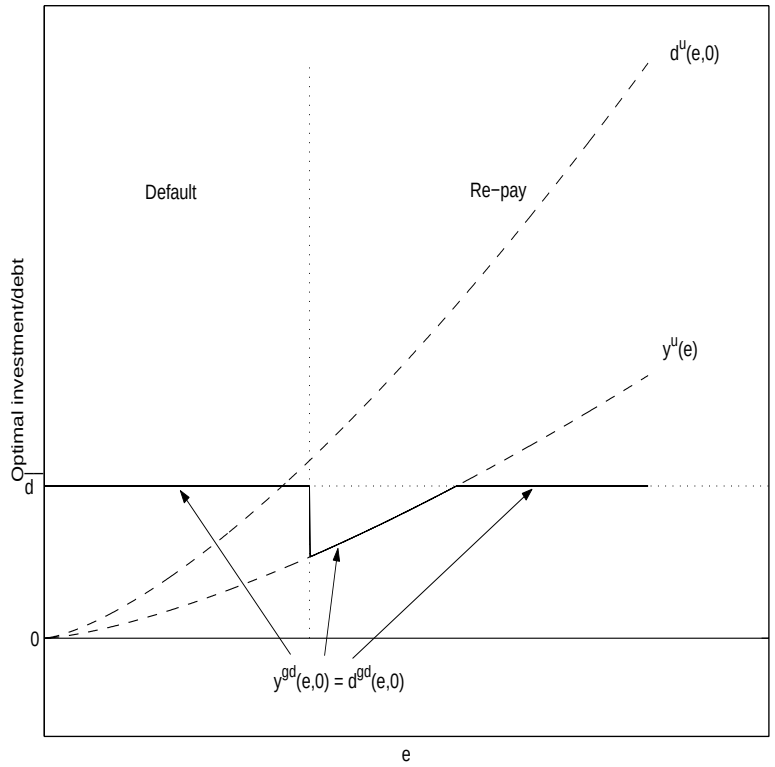
Optimal investment and default can be characterized in terms of ability. To simplify matters, assume $\underline{w} = 0$ so there is no minimum amount of earnings safe from creditors. In this case, define $\underline{e}$ as the ability level that equates the net earnings for investing $\bar{d}$ and defaulting with that associated with investing $y^u(e)$ and re-payment. Poor individuals (i.e. those with negligible assets) with ability less than $\underline{e}$ will borrow $\bar{d}$ and default. Now, define $\tilde{e}$ as the ability level for which $y^u(e) = \bar{d}$ (i.e. the person who would optimally invest $\bar{d}$ when he intends to re-pay his loan). A poor person with ability above $\tilde{e}$ is constrained from borrowing as much as he would like. Finally, let $\hat{e}$ represent the ability level at which someone is indifferent between re-paying and defaulting on a loan of size $\bar{d}$. Those with ability above $\hat{e}$ will re-pay a loan of size $\bar{d}$.[13]

Consider the case when $\gamma > \alpha$, so $\underline{e} < \hat{e} < \tilde{e}$.[14] For low a, optimal investment and default choices

[13]These ability thresholds for someone with negligible assets are mathematically given by $\underline{e} = \left(\frac{R}{\alpha}\right)\left(\frac{1-\gamma}{1-\alpha}\right)^{(1-\alpha)/\alpha}\bar{d}^{1-\alpha}$, $\tilde{e} = \left(\frac{R}{\alpha}\right)\bar{d}^{1-\alpha}$, and $\hat{e} = \left(\frac{R}{\gamma}\right)\bar{d}^{1-\alpha}$.

[14]If $\gamma \leq \alpha$, then $\tilde{e} \leq \underline{e} \leq \hat{e}$ and all individuals will invest and borrow the maximum $\bar{d}$; those with ability below $\hat{e}$ default while those above this cutoff re-pay their loans. Borrowers with ability less than $\tilde{e}$ over-invest, while those with ability above that threshold under-invest relative to the unconstrained optimal amount. Interestingly, since $\tilde{e} \leq \hat{e}$, middle ability individuals who choose to default – those with $e \in (\tilde{e}, \hat{e})$ – actually under-invest relative to the unconstrained optimal amount. When $\gamma = \alpha$, then $\underline{e} = \tilde{e} = \hat{e}$ and all individuals will invest and borrow $\bar{d}$; those with ability below the unique

Figure 4: Optimal Investment, Borrowing, and Default Decisions (for $a \approx 0$)



can be described as follows:

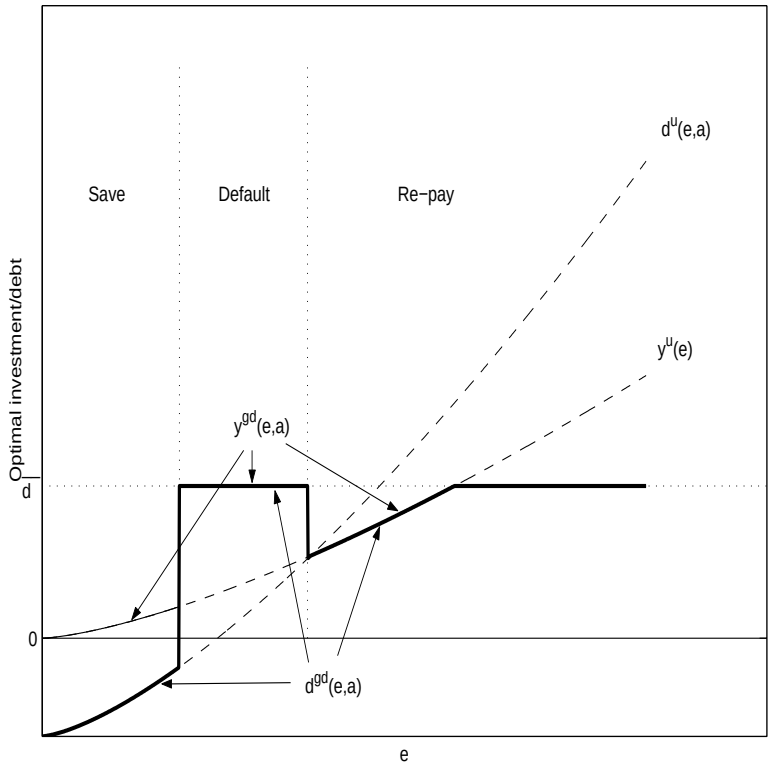
$$y^{gd}(e,a) = \begin{cases} \bar{d} & \text{if } e \leq \underline{e} \quad \text{(Default)} \\ y^u(e) & \text{if } e \in (\underline{e}, \tilde{e}) \quad \text{(Re-pay)} \\ \bar{d} & \text{if } e \geq \tilde{e} \quad \text{(Re-pay).} \end{cases}$$

Figure 4 graphically represents the case for individuals with negligible initial assets. Investment is clearly a discontinuous non-monotonic function of ability with three distinct regions. Only the low ability students default after borrowing the maximum. Middle ability students borrow the socially efficient amount ($y^u(e)$) and re-pay their loans, despite the fact that they are borrowing constrained. High ability students are limited to borrowing $\bar{d}$, and they re-pay their loans. We observe over-investment among the least able and under-investment among the most able. The option for default essentially introduces over-investment and default among low ability students. With no uncertainty, the option for default effectively transforms student loans into subsidies for investment among the least able poor.

The introduction of $\underline{w} > 0$ will increase both $\underline{e}$ and $\hat{e}$, increasing default rates and the fraction of people over-investing. If $\underline{w}$ becomes sufficiently large, all individuals will borrow the maximum and default.

cutoff over-invest and default while those above the cutoff under-invest and re-pay.

Figure 5: Optimal Investment, Borrowing, and Default Decisions (for $a > 0$)



Individuals of low ability with some initial assets may not need to borrow to cover their efficient investment amount. To the extent that they are not constrained from borrowing enough to finance $y^u(e)$, they may choose to invest efficiently and re-pay any small loans they may take out rather than borrow and invest the maximum and default. Thus, for a small but positive, there may be a region of very low ability for which investment is equal to $y^u(e)$. Slightly higher e individuals may find borrowing the maximum and defaulting optimal. As e increases further, we may again reach a region where optimal investment and re-payment is preferred. Finally, as e increases enough, we reach the region where low to middle wealth individuals are constrained by $\bar{d}$. An example of this type of investment profile is shown in Figure 5 along with the corresponding borrowing function. Notice, the investment profile is quite similar to that of Figure 4, except there is a region of optimal investment at the very low e end where individuals are saving.

Optimal Investment Under the GSL System with Uncertainty

Without uncertainty, the option for default only plays the role of a subsidy for investment at the low ability end, leading to over-investment in human capital. Introducing uncertainty in the returns to human capital introduces an insurance role for the option of default. To incorporate labor market (or

educational) uncertainty, suppose second period income is given by

$$w(z, e, y) = zey^{\alpha}, \tag{2}$$

where $z \geq 0$ is an education/labor market shock that occurs after investment decisions but before re-payment decisions are made. We now consider the same government student loan system with default in this uncertain environment. The uncertain garnishment schedule is given by $\max\{0, \gamma(zey^{\alpha} - \underline{w})\}$. The re-payment decision now depends on the realization of z, and effective re-payment is given by

$$P(z, e, y, d) = \min\{Rd, \max\{0, \gamma(zey^{\alpha} - \underline{w})\}\}.$$

As above, the option of default generates a non-convexity. To find the optimum, we must consider interior optima as well as corner solutions for investment. Assuming z has an atomless distribution $F(z)$, the first order condition for an interior optimum among poor students (i.e. those constrained by $d \leq y$) is

$$\alpha ey^{\alpha-1} \int zu'[\alpha zey^{\alpha-1} - P(z, e, y, y)]dF(z) = \int u'[\alpha zey^{\alpha-1} - P(z, e, y, y)]\frac{\partial P(z, e, y, y)}{\partial y}dF(z). \tag{3}$$

At most, one value of y can satisfy this condition. To find the globally optimal investment for these borrowers, one must compare the value attained from this local optimum with the one attained by investing the maximum, $y = \bar{d}$.

For any $\bar{d}$, agents with very low ability, e, may know they will default with almost certainty for any plausible level of investment. This can cause them to borrow the maximum and make substantial investments, since it is no more costly to default on the maximum than it is to default on a lesser amount. On the other hand, for high ability agents, the maximum loan amount may be less than they wish to invest. In this case, optimal investment may also equal $\bar{d}$ but for very different reasons. These agents will repay with very high probability. The model predicts that agents with extremely low and extremely high ability will both invest the maximum amount, but those with high ability will almost certainly repay while those with low ability will almost certainly default.

Does the probability of default then decline monotonically with ability? Not necessarily. Monotonicity of the probability of default is determined by monotonicity of the cutoff z_1 evaluated at the optimum,

$$z_1^*(e, a) \equiv \frac{Ry(e, a) - \underline{w}}{\gamma e(y(e, a))^{\alpha}}.$$

This threshold may be non-monotonic in e, since $y(e, a)$ is typically increasing in e. For any given investment/debt level, more able agents are more likely to repay, since the punishment of default is increasing in earnings conditional on investment. However, more able agents generally choose to borrow and invest more, making repayment more costly. As a result, the net effect of ability on default is ambiguous.

Discussion

Discuss:

- admissions requirements–may limit investment
- expenditures via foregone earnings vs. higher tuition – system favors latter
- incentives for schools to provide consumption goods and charge high tuition
- choice of college major?

4 Empirical Predictions for Default

5 Efficient Private Lending and Optimal Government Policy

6 A Quantitative Analysis

7 Conclusions

Appendix A: Baccalaureate and Beyond Survey

We use the Baccalaureate and Beyond Surveys (BB) to analyze patterns in default on student loans by college graduates a few years out of college. The survey has followed a random sample of about 11,000 individuals who received their baccalaureate degree during the 1992-93 academic year through 1997 (with surveys in 1993, 1994, and 1997).[15] We also disregard individuals receiving their BA at age 30 or later to focus on the traditional college student (less than 15% received their BA at such late ages). Because those continuing on to graduate school are eligible for deferments in their loan re-payment, we do not observe the default choices of individuals enrolling in graduate school for more than a short time. We, therefore, focus on U.S. citizens receiving no more than 9 months of graduate education and who are no longer enrolled in any form of school as of the 1997 survey (maintaining about two-thirds of the sample).

Approximately 50% of these graduates report having borrowed money for their schooling, and we focus on them. Our main sample, therefore, consists of 2,796 undergraduate borrowers who graduated from college in the 1992-93 academic year and did not pursue more than 9 months of post-graduate education.

[15]The BB sample is a subsample consisting of all graduating respondents from the 1993 National Postsecondary Student Aid Study (NPSAS), a nationally representative sample of all postsecondary students in the U.S. All averages in the following tables are weighted to reflect the stratified sampling scheme of the original NPSAS survey as well as any attrition in later surveys.

To measure default, we determine whether or not an individual defaulted on (and did not subsequently re-pay) or expunged through bankruptcy any federal student loan through early 1998.[16] Loan amounts are based on survey responses in 1997 and include any borrowing from federal or private sources (including the family). The 1994 and 1997 surveys ask respondents about their earnings at their current job. We calculate their annual earnings and wage rates for the job at which they were employed at the time of these surveys. Respondents also reported household income for the year prior to the 1994 and 1997 surveys.

Table A-1 reports background characteristics for our sample of borrowers. It is nearly equally split along gender lines, with more than 80% white. About one-fourth of the sample majored in business and management. Table A-2 reports the extent of borrowing and post-school earnings/employment. Among the borrowers in this sample, average undergraduate loans totaled about $10,500, while graduate loans were negligible (reflecting our sample requirement that they have no more than 9 months of graduate study). Approximately 27% had taken out loans of less than $5,000, and 24% had loans of $15,000 or more. When spousal loans are added on for those who were married, average family educational borrowing was nearly $13,000. Four years after receiving their BA, these borrowers still owed more than $4,500 on their own student loans and their families owed a total of almost $6,000. Nearly 6% of these borrowers had defaulted on (and not subsequently re-paid) at least one of their college loans.

Average earnings for the sample of borrowers one year out of college was $20,790 (1994), increasing to $31,599 four years after graduation (1997).[17] Wage rates in the 1997 job averaged $14.77, and most had experienced little if any time unemployed. Household income averaged about $45,000 in 1996. Since low incomes may indicate an inability to make loan payments, it is instructive to note that 36% of the college graduates earned less than $25,000 in 1997 while slightly less than 20% had total family income below that level during the previous year.

[16] These data, collected for the BB, are based on individual loan records from the National Student Loan Data System (NSLDS) as of 1998. They report the status of each federal student loan taken out by all borrowers in the sample.

[17] These measures include those with zero earnings–only a very small fraction of the sample.

Table A-1: Sample Background Characteristics for Undergraduate Borrowers

Variable	N	Mean	Standard Error
Male	2,796	0.474	0.009
White	2,783	0.825	0.007
Black	2,783	0.079	0.005
Hispanic	2,783	0.061	0.005
Asian	2,783	0.029	0.003
SAT/ACT Quartile 1	2,464	0.277	0.009
SAT/ACT Quartile 2	2,464	0.290	0.009
SAT/ACT Quartile 3	2,464	0.241	0.009
SAT/ACT Quartile 4	2,464	0.193	0.008
Major: business/management	2,795	0.248	0.008
Major: education	2,795	0.125	0.006
Major: engineering	2,795	0.074	0.005
Major: health professions	2,795	0.076	0.005
Major: public affairs/social services	2,795	0.031	0.003
Major: biological sciences	2,795	0.037	0.004
Major: math & science	2,795	0.062	0.005
Major: social science	2,795	0.078	0.005
Major: history	2,795	0.015	0.002
Major: humanities	2,795	0.076	0.005
Major: psychology	2,795	0.028	0.003
Major: other	2,795	0.151	0.007

Notes:
Sample includes all U.S. citizens who did not report a disability, had no more than 9 months of graduate education, were not currently enrolled in school, received their BA prior to age 30, and borrowed money for their education.

Table A-2: Debt and Earnings for Undergraduate Borrowers

Variable	Mean	Standard Deviation
(a) Debt/Loans (as of 1997):		
Any graduate loans	0.012	0.108
Any outstanding loan balance	0.649	0.477
Any family outstanding loan balance	0.682	0.466
Any other debt	0.970	0.171
Total undergraduate loan amount	10,527	9,238
Total loan amount	10,687	9,493
Educational debt $1-4,999	0.265	0.441
Educational debt $5,000-9,999	0.275	0.446
Educational debt $10,000-14,999	0.216	0.411
Educational debt $15,000-19,999	0.125	0.331
Educational debt $20,000 +	0.119	0.324
Total family loan amount	12,598	12,121
Amount still owed on loans	4,562	5,904
Amount family still owes on loans	5,910	8,572
Amount of other debt	956	578
Tuition paid for 1992-93 year	4,484	4,721
Default (without re-payment)	0.056	0.231
(b) Earnings and Employment:		
1994 earnings	20,790	39,131
longest unemployment spell from BA to 1994 survey (months)	1.502	3.048
1997 earnings	31,599	21,514
longest unemployment spell from BA to 1997 survey (months)	2.651	5.211
1997 wage rate	14.77	13.79
1996 family income	44,984	27,157
1997 earnings less than $25,000	0.360	0.480
1996 family income less than $25,000	0.196	0.397
Family income less than $25,000 in 1993 or 1996	0.680	0.466
Family income higher than $25,000 in 1993 or 1996	0.819	0.385
Ratio of total education loans to 1997 earnings	3.405	196.800
Ratio of family education loans to 1996 income	1.771	97.236

Notes:
Sample includes all U.S. citizens who did not report a disability, had no more than 9 months of graduate education, were not currently enrolled in school, received their BA prior to age 30, and borrowed money for their education.

References

[1] S. R. Aiyagari, J. Greenwood, and A. Seshadri. Efficient Investment in Children. *Journal of Economic Theory*, forthcoming.

[2] F. Alvarez and U. Jermann. Asset Pricing when Risk Sharing is Limited by Default. Working Paper, University of Chicago and The Wharton School, 1997.

[3] G. Becker. *Human Capital*. Columbia University Press, New York, 1964.

[4] G. Becker. *Human Capital*. University of Chicago Press, Chicago, 3rd edition, 1993.

[5] College Board. *Trends in Student Aid*. College Board Publications, New York, 2001.

[6] M. Browning, L. Hansen, and J. Heckman. Micro Data and General Equilibrium Nodels. In J. Taylor and M. Woodford, editors, *Handbook of Macroeconomics*, volume 1A, chapter 8. North-Holland, New York, 1999.

[7] S. Cameron and J. Heckman. Life Cycle Schooling and Dynamic Selection Bias: Models and Evidence for Five Cohorts of American Males. *Journal of Political Economy*, 106(2):262–333, April 1998.

[8] S. Cameron and C. Taber. Borrowing Constraints and the Returns to Schooling. Working Paper, 1999.

[9] D. Card. Earnings, Schooling, and Ability Revisited. *Research in Labor Economics*, 14:23–48, 1995.

[10] P. Carniero and J. Heckman. The Evidence on Credit Constraints in Schooling. Working Paper, 2002.

[11] E. Caucutt and K. Kumar. Higher Education Subsidies and Heterogeneity. Working Paper, 2000.

[12] E. Hanushek, K. Yilmaz, and C. Leung. Redistribution Through Education and Other Transfer Mechanisms. Working Paper, 2001.

[13] M. Keane and K. Wolpin. The Effect of Parental Transfers and Borrowing Constraints on Educational Attainment. 2001.

[14] T. Kehoe and D. Levine. Debt-Constrained Asset Markets. *Review of Economic Studies*, 60(4):865–88, Oct. 1993.

[15] N. Kocherlakota. Implications of Efficient Risk Sharing without Commitment. *Review of Economic Studies*, 63(4):595–609, 1996.

[16] L. Lochner and A. Monge-Naranjo. Human Capital Formation with Endogenous Credit Constraints. Working Paper, 2002.

[17] US Department of Education. Accountability for Results Works: College Loan Default Rates Continue to Decline. Press Release, September 19, 2001.