Credit Constraints in Education

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Abstract

We review studies of the impact of credit constraints on the accumulation of human capital. Evidence suggests that credit constraints have recently become important for schooling and other aspects of households' behavior. We highlight the importance of early childhood investments, as their response largely determines the impact of credit constraints on the overall lifetime acquisition of human capital. We also review the intergenerational literature and examine the macroeconomic impacts of credit constraints on social mobility and the income distribution. A common limitation across all areas of the human capital literature is the imposition of ad hoc constraints on credit. We propose a more careful treatment of the structure of government student loan programs and the incentive problems underlying private credit. We show that endogenizing constraints on credit for human capital helps explain observed borrowing, schooling, and default patterns and offers new insights about the design of government policy.

1. INTRODUCTION

Education and other human capital investments are central to both individual and economy-wide development. By limiting the incentives and capacity to invest in human capital, credit constraints play an important role in determining social mobility, the distribution of income, and economic growth and development (Becker 1975). This article reviews recent research in both the micro and macro literatures on human capital investment and credit constraints.

In Section 2, we use a two-period model to examine frequently tested implications of constraints for schooling. US-based evidence on the impacts of credit constraints on college-going, as well as consumption and work during college, is reviewed in Section 3. Evidence suggests that the increases in college costs and returns over the past two decades have increasingly pushed more youth up against their credit limits.

Recent US studies suggest that borrowing constraints may be more harmful for investments in young children. We review this evidence in Section 4 and discuss the benefits of considering multiperiod investments in human capital. The high estimated degree of complementarity between early and late investments suggests that postsecondary aid policies may come too late to help many youth from disadvantaged families.

Section 5 reviews intergenerational studies in which borrowing constraints determine social mobility and the distribution of income. Some of these studies also quantify the impacts of education-based government policies on these outcomes. Although recent studies are pessimistic about the benefits of additional subsidies for higher education, new efforts to help finance earlier investments offer more promise.

Ad hoc assumptions about credit constraints constitute a common limitation across all areas of the human capital literature. In Section 6, we propose a more careful treatment of government loan programs and the incentive problems underlying private credit. We show that endogenizing credit constraints for human capital helps explain certain features of the data. We also demonstrate how the modern literature on optimal contracts under limited commitment and private information can help provide new insights about the behavior of human capital investments and the design of government programs.

2. HUMAN CAPITAL WITH EXOGENOUS BORROWING CONSTRAINTS

In this section, we consider a basic human capital model in which investments increase future earnings but provide no additional utility benefits/costs. The model also abstracts from the choice of leisure time. This canonical framework is useful for discussing many key economic trade-offs, and its sharp predictions serve as the starting point for most empirical studies in the literature on education and borrowing constraints. We next discuss how the incorporation of nonpecuniary costs/benefits of human capital affects the interpretation of many empirical studies in this area, as discussed further in Section 3. We also briefly discuss the impacts of borrowing constraints on other margins, including consumption, leisure, and school quality.

2.1. A Basic Model

Consider two-period-lived individuals who invest in schooling in the first period and work in the second. Preferences are

$$U = u(c_0) + \beta u(c_1), \tag{1}$$

where c_t is consumption in periods $t \in \{0,1\}$, $\beta > 0$ is a discount factor, and $u(\cdot)$ is strictly increasing and concave and satisfies standard Inada conditions.

Each person is endowed with financial assets $W \geq 0$ and ability $a > 0$.[1] Initial assets capture all familial transfers, whereas ability reflects innate factors, early parental investments, and other characteristics that shape the returns to investing in schooling. We take (W,a) as given to focus on schooling decisions that individuals make on their own; however, central results can be generalized to an intergenerational environment in which parents endogenously make transfers to their children (see Lochner & Monge-Naranjo 2011b).

During the schooling period, individuals make human capital investments h that increase postschool labor earnings $y = w_1 af(h)$. Each unit of h entails forgone wages $w_0 \geq 0$ and tuition costs $\tau > 0$; w_1 is the price of human capital, and $f(\cdot)$ is positive, strictly increasing, and concave. A higher ability a increases total and marginal returns to investment.[2]

Young individuals can borrow d (or save, in which case $d < 0$) at a gross interest rate $R > 1$. Consumption levels in each period are

$$c_0 = W + w_0(1-h) - \tau h + d, \tag{2}$$

$$c_1 = w_1 af(h) - Rd. \tag{3}$$

2.1.1. Unrestricted optima. In the absence of credit market frictions, individuals maximize utility (Equation 1) subject to Equations 2 and 3. Human capital investment maximizes the present value of net lifetime income, equating its marginal return with that of financial assets:

$$\frac{w_1 af'\left[h^U(a)\right]}{w_0 + \tau} = R. \tag{4}$$

Optimal unrestricted investment $h^U(a)$ is strictly increasing in ability a and independent of initial assets W.

Unconstrained optimal borrowing $d^U(a,W)$ smooths consumption over time, satisfying the Euler equation

$$u'\left[W + w_0 + d^U(a,W) - (w_0+\tau)h^U(a)\right] = \beta R u'\left[w_1 af\left[h^U(a)\right] - Rd^U(a,W)\right], \tag{5}$$

where $W + w_0$ reflects full wealth if no time is devoted to schooling. Unconstrained borrowing strictly decreases in wealth and increases in ability. Greater ability increases borrowing for two distinct reasons: (*a*) More-able individuals wish to finance more investment, and (*b*) given any level of investment, more-able individuals earn higher net lifetime income and wish to consume more in the first period. Analogously, an increase in the return on investment w_1 leads to an increase in desired borrowing for everyone.

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[1]Evidence suggests that multiple skills/abilities are important in the labor market and help determine schooling decisions (see, e.g., Carneiro et al. 2011). Accounting for multiple abilities would not change the substance of most theoretical results in this section, but it can be important for measuring the empirical relevance of constraints.

[2]Although there is no natural metric for ability a, this is consistent with commonly used separability between ability and human capital investment in log wages. Results discussed in this section generalize to an earnings specification $y = w_1 f(a,h)$, where $f(\cdot)$ is positive, strictly increasing, and concave in both arguments, and $\frac{\partial^2 f}{\partial a \partial h} > 0$.

2.1.2. Borrowing constraints. Now consider an exogenously specified upper limit on the amount of debt that individuals can accumulate:

$$d \le \bar{d}, \tag{6}$$

where $0 \le \bar{d} < \infty$. This ad hoc restriction is common in the literature on borrowing constraints and human capital. In Section 6, we discuss more realistic constraints derived explicitly from government student loan (GSL) programs and limited commitment problems in private lending markets.

The equation $d^U(a,W) = \bar{d}$ implicitly defines a threshold level of assets $W_{\min}(a)$ determining who is constrained $[W < W_{\min}(a)]$ and who is unconstrained $[W \ge W_{\min}(a)]$. Constrained persons have high ability relative to their wealth—$W_{\min}(a)$ is increasing in ability. Importantly, being unconstrained may require much higher wealth W than is necessary to cover tuition, as individuals also borrow to smooth consumption [i.e., $W + w_0 > \tau\, h$ does not ensure that $d^U(a,W) < \bar{d}$].

When the borrowing constraint binds, all possibilities to bring future resources to the early (investment) period have been exhausted. Then optimal investment h^X satisfies

$$(w_0 + \tau)u'\left[W + w_0 - (w_0 + \tau)h^X + \bar{d}\right] = \beta u'\left[w_1 a f(h^X) - R\bar{d}\right] w_1 a f'(h^X). \tag{7}$$

The implied function $h^X\,(a,\, W)$ strikes a balance between increasing lifetime earnings and smoothing consumption, yielding a number of predictions that have been extensively examined in the empirical literature.

2.1.3. Empirical predictions. Assume the constraint given in Equation 6 binds when referring to $h^X\,(a,W)$. Then we have the following results:

1. Constrained individuals underinvest in their human capital: $h^X\,(a,W) < h^U\,(a)$.
2. Unconstrained investment $h^U\,(a)$ is independent of wealth W, whereas constrained investment $h^X\,(a,W)$ is strictly increasing in wealth and the borrowing limit $\bar{d}$.
3. The marginal return on human capital $MR(h) \equiv \frac{w_1 a f'[h]}{w_0 + \tau}$ is equal to the return on savings R for unconstrained individuals and is strictly greater than R and strictly decreasing in wealth W for constrained individuals.
4. Constrained investment $h^X\,(a,W)$ decreases more with an increase in direct costs, τ, than with an equal increase in opportunity costs, w_0 (i.e., $-\partial\, h^X/\partial w_0 < -\partial h^X/\partial\tau$). Unconstrained investment responds equally to both costs (i.e., $\partial\, h^U/\partial\, w_0 = \partial\, h^U/\partial\tau$).

These results follow from implicit differentiation of Equations 4 and 7. The first three are well-known since Becker (1967). They derive from the fact that the marginal cost of investment is higher for constrained individuals, as they cannot borrow to smooth consumption over time. This causes constrained individuals to invest less, stopping school when the marginal return is still relatively high. The fourth implication is derived by Cameron & Taber (2004) in a slightly different setting. Here it derives from the fact that an increase in opportunity costs also raises full wealth levels, whereas an increase in direct costs does not.[3] We discuss empirical evidence related to these results in Section 3.

[3]This asymmetry is more easily seen when investment can take only two values, $h \in \{0, 1\}$. In this case, an increase in opportunity costs lowers resources in the no-schooling case when consumption is relatively high, whereas an increase in tuition reduces resources in the schooling case when consumption is relatively low.

Predictions about the relationship between ability and constrained human capital investment h^X are rarely discussed in the literature. Lochner & Monge-Naranjo (2011b) show that this relationship is shaped by two opposing forces: (*a*) More-able individuals earn a higher return on human capital investment, so they would like to invest more, and (*b*) more-able individuals have higher lifetime earnings, so they would like to consume more at all ages. This discourages investment, as constrained borrowers can only increase early consumption by lowering investment. With empirically relevant preferences for intertemporal consumption smoothing, the second effect can dominate, and constrained investments would be decreasing in ability.[4]

2.2. Incorporating Tastes for Schooling

To introduce nonpecuniary benefits/costs of education (denoted by ξ) to the model above, augment utility so $U = u\,(c_0) + \beta u\,(c_1) + \xi h$. The introduction of nonpecuniary benefits ($\xi > 0$) or costs ($\xi < 0$) implies that unconstrained investment is not generally independent of wealth W. Indeed, $\frac{\partial h^U}{\partial W} > 0$ and $MR(h^U) < R$ for $\xi > 0$, whereas $\frac{\partial h^U}{\partial W} < 0$ and $MR(h^U) > R$ for $\xi < 0$.[5] As such, results 2 and 3 derived above no longer imply simple tests for borrowing constraints. Low-wealth individuals may acquire low levels of schooling (and have a high marginal return to investment) because they are more likely to be constrained or because schooling offers nonpecuniary benefits. In contrast, result 4 is robust to the inclusion of nonpecuniary tastes, so tests for constraints based on the relative responsiveness of investment to the direct and opportunity costs of schooling (e.g., Cameron & Taber 2004) may be more informative.

The empirical literature that incorporates unobserved heterogeneity in nonpecuniary tastes typically considers a discrete set of human capital investment choices (e.g., high school versus college attendance).[6] Belley & Lochner (2007) show that in the absence of borrowing constraints, the observed relationship between family resources and college attendance depends on the correlation between ξ and W as well as the net financial returns to college.[7] Importantly, given any stable relationship between tastes for schooling and family resources, the correlation between family resources and the probability of attendance (conditional on ability) should weaken (or become negative) as the net financial returns to college increase. Intuitively, an increase in the return to college raises the relative value of college less for individuals with high wealth because of the diminishing marginal utility of consumption.[8] This need not be true when borrowing constraints limit the

[4]This result also implies that an increase in the price of human capital w_1 should lead to aggregate reductions in investment among constrained individuals.

[5]Result 1 (i.e., $h^X < h^U$) and comparative statics for constrained investment h^X in results 2 and 3 continue to hold.

[6]Cunha et al. (2005) and Navarro (2010) argue that heterogeneity in nonpecuniary factors is necessary to explain choices given the distribution of youth abilities and information about future earnings prospects. Heterogeneity in other preference parameters (e.g., discount rates, risk aversion, value of leisure) may also be important for explaining schooling allocations (Almlund et al. 2011).

[7]Letting $h \in \{0, 1\}$ reflect high school versus college attendance, if net financial returns $N(a) \equiv -\tau + R^{-1}w_1 af(1) - [w_0 + R^{-1}w_1 af(0)] > 0$ and $\xi \perp\!\!\!\perp W$, then the probability of college attendance should be decreasing in W conditional on a.

[8]A similar result holds for an increase in the nonwage benefits of work for college relative to high school jobs as long as individuals have diminishing marginal utility for those benefits. However, the wealth–attendance gradient could increase over time if the nonwage benefits of college jobs became relatively more valuable for wealthier individuals.

consumption of low-wealth individuals. Constrained youth may benefit little from an increase in future labor market returns to school, since additional postschool earnings cannot be used to increase consumption during school when it is most valuable. As discussed below, these results are helpful for interpreting recent changes in family income–college attendance relationships in light of the contemporaneous increase in returns to college.

2.3. Other Margins: Consumption, Leisure, and School Quality

Credit constraints may affect other choices. Constrained youth are likely to have low levels of consumption during school, and they may substitute leisure for work to alleviate the negative impacts of constraints on consumption and investment. Constrained youth may also choose to delay college entry (and its labor market rewards) to accumulate savings.

Finally, youth may adjust on the school quality margin given any level of attendance. The model above does not distinguish between school quality and quantity; however, abstracting from opportunity costs (i.e., $w_0 = 0$), one can simply reinterpret h as the quality of school conditional on school attendance. (Readers are referred to Epple et al. 2006, Avery & Turner 2010, Chade et al. 2011, and Fu 2011 for explicit analyses of college quality choice.) With this interpretation, constrained youth should attend lower-quality institutions, with quality increasing in wealth and the borrowing limit. This implies that wage returns from college attendance should be lower for constrained youth, as they effectively invest less at lower-quality schools. As noted by Carneiro & Heckman (2002), this prediction contrasts sharply with result 3 (i.e., that the marginal wage return to investment is higher for constrained youth).

3. US EVIDENCE ON BORROWING CONSTRAINTS AND COLLEGE

The rising costs of and labor market returns to college in the United States since the early 1980s, coupled with stable real GSL limits, suggest that borrowing constraints may be more salient now than 30 years ago. Consistent with this view, 26% of all dependent undergraduate students at four-year public universities in the United States were borrowing the maximum allowable amount from the Stafford Loan Program in 1999–2000, compared with under 4% 10 years earlier.[9] To help meet increased student demand for funds, private student credit increased rapidly from virtually zero in the early 1990s to 9% of all student loan dollars distributed in 1999–2000 (College Board 2004). We review US-based evidence on the impacts of credit constraints on educational attainment, college quality, work while in school, and consumption allocations.

3.1. Differences in Schooling Decisions by Family Income/Wealth

Many economists have examined the wide disparities in education by parental income, education, and race to gauge the impact of borrowing constraints on education decisions. The following discussion focuses on the role of family income as a determinant of post–secondary education outcomes.

[9]GSL figures are taken from Titus (2002, tables 2.1 and 2.7). Stafford Loans (and the earlier Supplemental Loans to Students) are the main source of government loans for undergraduates.

Studies based on the 1979 cohort of the National Longitudinal Survey of Youth (NLSY79) generally find that family income played little role in college-attendance decisions (after controlling for adolescent ability and family background) during the early 1980s (Cameron & Heckman 1998, 1999; Carneiro & Heckman 2002). Comparing education behaviors in the NLSY79 with the 1997 cohort of the NLSY (NLSY97), Belley & Lochner (2007) find that family income has become a much more important determinant of college attendance in the early 2000s.[10] Youth from high-income families in the NLSY97 are 16 percentage points more likely to attend college than are youth from low-income families, conditional on adolescent cognitive achievement and family background. This is roughly twice the effect observed in the NLSY79. The increased importance of income is mostly among lower- and middle-ability youth.

The NLSY79 does not contain data on wealth. In the NLSY97, the combined effects of family income and wealth on college attendance are roughly double the effects of income alone (Belley & Lochner 2007).[11] To address concerns about the endogeneity of family wealth, Lovenheim (2011) uses data from the Panel Survey of Income Dynamics (PSID) to estimate the impacts of exogenous changes in housing wealth (driven by local housing booms and busts) on postsecondary enrollment decisions. His estimates suggest that an additional $10,000 in housing equity raises college enrollment by 0.7 percentage points, with much larger effects among lower-income families. He also finds that the impacts of housing wealth have become more important in the 2000s; however, it is unclear whether this results from the increased liquidity of housing wealth or from a general increase in the effect of family resources on schooling.

Belley & Lochner (2007) also use the NLSY79 and NLSY97 to examine the changing role of family income for other college-related choices. Among lower-ability groups, they estimate weak effects of income on work (during the school year) for both NLSY cohorts. Among the most able, the effects of income on work increase substantially over time. In the NLSY97, the most-able youth from low-income families work more weeks and nearly twice as many hours per week during the school year than their higher-income counterparts. The estimated effects of family income on college-entry delay are weak for both NLSY cohorts.[12]

The relationship between family income and the type of postsecondary institution individuals attend has changed since the early 1980s. Whereas family income had little effect on the choice of two-year versus four-year institutions in the NLSY79, students from the highest-income quartile in the NLSY97 are 11 percentage points more likely to be attending a four-year institution than their counterparts from the bottom quartile, conditional on ability and family background (Belley & Lochner 2007).[13] By contrast, the relationship between family income and attendance at selective high-quality institutions appears to have weakened over this same period. Kinsler & Pavan (2010) estimate that

[10]Ellwood & Kane (2000) argue that college-attendance differences by family income were already becoming more important by the early 1990s.

[11]NLSY97 youth from the highest-family-income and -wealth quartiles are nearly 30 percentage points more likely to attend college than those from the lowest-income and -wealth quartiles (controlling for ability and family background).

[12]The estimated effects of income on college-entry delay and institution type for the NLSY79 are consistent with those of Carneiro & Heckman (2002).

[13]Lovenheim & Reynolds (2011) also use the two NLSY cohorts to explore more detailed trends in college enrollment by institution type.

(conditional on ability and family background) moving from the bottom to top income quartile increased the probability of attending a top quality college by approximately 25 percentage points in the NLSY79 and by only 16 percentage points in the NLSY97.

Among top (often private) schools, the sharp increases in tuition since the early 1980s were generally accompanied by increases in financial aid for lower-income students. This effectively increased the price of college quality more for high-income students relative to their lower-income counterparts. This highlights that need-based grants affect college attendance and quality decisions through price effects as well as by providing liquidity.[14] Both effects weaken the relationship between family income and attendance or quality. Complicating the role of financial aid, many low-income youth may be poorly informed about aid opportunities or may find it difficult to fill out complex financial aid forms (Dynarski & Scott-Clayton 2006, Bettinger et al. 2009, Avery & Turner 2010).

One explanation for the observed positive relationship between family income and schooling is that higher-income families place greater value on education. However, it is not clear why this relationship would have strengthened so much since the early 1980s. As discussed in Section 2.2, the increase in net returns to schooling should have weakened the income–attendance relationship in the absence of borrowing constraints (if the relationship between tastes for college and family income had remained stable).

3.2. Differential (Marginal) Returns to Schooling

As Card (1999) notes, many instrumental variables (IV) estimates of the wage return to schooling exceed ordinary least squares (OLS) estimates by 20%–30%. Based on the local average treatment effect (LATE) interpretation of IV, Lang (1993) and Card (1995, 1999) conjecture that borrowing constraints may explain this finding, as the instruments used largely impact the decisions of low-income and potentially constrained youth. It is argued that these IV estimators may reflect relatively high marginal returns for constrained youth, whereas OLS estimates more closely reflect average returns in the population. However, Carneiro & Heckman (2002) show that this is not generally the case with heterogeneous returns to schooling and self-selection.[15] Furthermore, marginal costs and returns to schooling may differ for reasons other than borrowing constraints, e.g., heterogeneity in tastes for schooling. Unfortunately, it is difficult to draw firm conclusions on the importance of borrowing constraints from this literature.

Cameron & Taber (2004) also examine returns to schooling, basing their analysis on results 3 and 4 in Section 2.1.3. They argue that the set of individuals whose college-going is affected by a change in direct costs (measured by whether there is a college in the individual's county of residence) should disproportionately include more credit-constrained youth than the set of individuals affected by a change in opportunity costs (measured by local low-skill wage rates). Thus, IV estimates of the return to schooling using "college in county" as an instrument should exceed those using local low-skill wages (ignoring differences in

[14]Belley et al. (2011) provide a detailed accounting of net price and out-of-pocket expenditures for college by family income in the United States and Canada.

[15]Carneiro & Heckman also raise other objections, including the use of weak or invalid instruments and the potential for differences in school quality to affect the relative returns for constrained and unconstrained students. Carneiro et al. (2011) provide a clear analysis of treatment effects identified from the use of different instrumental variables in the college-going context. Heckman (2010) provides for a more general discussion.

college quality) if borrowing constraints are important.[16] Examining men from the NLSY79, they find no evidence in support of credit constraints.

3.3. Structural Models

A few studies estimate life-cycle schooling models that exploit data on schooling choices, earnings, and, in some cases, assets and family transfers to identify the role of borrowing constraints. By estimating preferences, human capital production technology, and other factors determining educational choices, this approach facilitates the evaluation of a wide range of potential policies.

Cameron & Taber (2004) estimate a life-cycle model with a discrete set of schooling options and test whether individuals face different interest rates when making their schooling decisions. In their model, evidence that some individuals face high interest rates relative to others would imply that borrowing constraints distort their education decisions. The main sources of identification for interest-rate differences are the asymmetric impacts of opportunity costs and direct costs as discussed above. Consistent with their IV analysis, they find no heterogeneity in interest rates for their sample of NLSY79 men.

Keane & Wolpin (2001) estimate a dynamic model of schooling, work, and consumption in a framework that incorporates borrowing constraints and parental transfers. They use panel data on schooling and work (full-time and part-time), wages, and assets for white males in the NLSY79. Importantly, Keane & Wolpin allow for unobserved heterogeneity in the ability to acquire human capital, tastes for work and school, and borrowing limits.

Estimated borrowing limits are tight (ranging from \$600 to \$1,000 across individuals, in 1987 dollars)—less than one-third the estimated cost of a single semester of school (approximately \$3,700). Not surprisingly, their simulations indicate an important role for parental transfers and part-time work in enabling school attendance. They estimate that parents provide between \$3,300 and \$10,000 in transfers while students are enrolled in school, with transfers increasing in parental education. Transfers are estimated to be substantially lower when students are not enrolled in school. Hence, a sizeable portion of parental transfers effectively acts as a subsidy for education—a subsidy that is much larger for children with more educated parents. Based on a series of simulations, Keane & Wolpin conclude that nearly all the (sizeable) differences in educational attainment by parental education are accounted for by higher enrollment-contingent parental transfers and unobserved heterogeneity. Increases in available credit have negligible effects on schooling, but they reduce work and increase consumption during school.

Johnson (2011) uses data on recent male high school graduates in the NLSY97 to estimate a similar decision model with a few important extensions. He explicitly models GSL programs as well as a private credit limit, allows for differences in tuition across states, incorporates need- and merit-based grants, and allows for exogenous unemployment. Most importantly, he exploits additional data on average tuition by state and data on reported grant aid and parental transfers in the NLSY97.[17] He is able to infer

[16]This argument is based on the LATE interpretation of IV estimators. Carneiro et al. (2011) empirically show that both these instruments identify the effects of schooling for similar subpopulations.

[17]Like Keane & Wolpin (2001), he also uses data on schooling, work, assets, and wages. Because many of his respondents are still quite young, Johnson (2011) uses wages at ages 25+ from the NLSY79 cohort in estimation. This effectively yields estimates that average the returns to schooling and experience across the two NLSY cohorts.

consumption during and after school, which helps identify who may or may not be constrained. His data allow him to directly estimate parental transfer functions and student aid by parental income, whereas Keane & Wolpin (2001) infer parental transfers indirectly from schooling and work choices (and asset levels in later years).

Some of Johnson's main findings are similar to those of Keane & Wolpin (2001): Schooling-contingent parental transfers are greater for higher-income families and, along with unobserved heterogeneity, are important determinants of schooling. Although Johnson's estimated borrowing limits are modest relative to college costs, they are substantially greater than those of Keane & Wolpin (2001).[18] Despite greater borrowing opportunities, Johnson estimates a stronger, although still modest, impact of increasing loan limits. Simulations suggest that an additional $1,500 in credit per year in school (for everyone) would increase college completion rates by 4.5%. Allowing students to borrow up to the total costs of schooling would increase completion rates by nearly 8%. Given the low cost of extending GSL programs, Johnson (2011) estimates that increasing loan limits would have a greater impact on college outcomes than an increase in education subsidies costing the same amount.

Borrowing constraints have small to modest impacts on schooling choices in these two studies for very different reasons. As discussed above, estimates from Keane & Wolpin (2001) suggest that most students are constrained but that consumption and leisure are distorted rather than schooling. That schooling is unaffected by borrowing constraints is not surprising given other evidence based on the NLSY79. It is more surprising that Johnson (2011) estimates that increasing borrowing limits would have only modest effects on college completion given the increased importance of family income in the NLSY97. Despite the fact that credit opportunities plus parental transfers allow for, at best, modest consumption during school, Johnson estimates that few youth borrow up to their limit. In his model, risk aversion, coupled with the possibility of very low income (associated with postschool unemployment), prevents individuals from taking on much debt. His estimates suggest that very few would choose to borrow more than $6,000.[19]

Navarro (2010) also explores the importance of heterogeneity, uncertainty, and borrowing constraints as determinants of college attendance in a life-cycle framework. At each age, borrowing constraints are given by the lowest possible discounted future income [i.e., the "natural" limit of Aiyagari (1994)].[20] An important innovation of this work is the empirical methodology used to identify ex ante heterogeneity in abilities (and unobserved tastes for college) separately from uncertainty about future income. Using schooling and earnings data from the NLSY79 and PSID, Navarro estimates distributions of actual returns to college, expected returns to college, and tastes for college. Because individuals would never choose to borrow more than the natural limit, relaxing this constraint by itself would have no effect on behavior in his framework. His estimates suggest that eliminating uncertainty would substantially change who attends college but would have little impact on the aggregate attendance rate. Most interesting, he finds that simultaneously removing uncertainty and borrowing constraints would lead to sizeable increases

[18]Youth attending college for four years can borrow up to $23,000 from the Stafford Loan Program plus as much as an estimated $11,700 in private loans.

[19]Although his model matches the fraction of 25-year-olds with net debt, it substantially underestimates the fraction of youth with modest or high levels of debt.

[20]Empirically, he incorporates income transfers at each age so that the natural borrowing limit equals the lowest level of observed debt in his data.

in college attendance, pointing out an important interaction between borrowing constraints and risk/uncertainty.

Assumptions about minimal income (or consumption) levels are crucial for the importance of borrowing limits in life-cycle schooling models with uncertainty. The demand for credit may be much higher with explicit insurance mechanisms or implicit ones such as bankruptcy, default, or other options (e.g., deferment and forgiveness in GSLs). Of course, private credit offerings may increase in response to any reductions in risk. A better understanding and recognition of these issues in research on credit constraints and education are needed, as we discuss in Section 6.

The results of Keane & Wolpin (2001) and Johnson (2011) suggest that many youth would not attend college without schooling-contingent transfers from their parents, even if credit were abundant. So why do wealthier parents effectively subsidize so much schooling if their children are not willing to pay for it themselves? Taken at face value, these results suggest that many parents must value their children's education more than their children do. This gives rise to three potential explanations for the strong positive relationship between parental income/education and schooling-contingent subsidies: (*a*) All parents have similar tastes for schooling, but poor parents may be constrained in what they can afford to pass on to their children. (*b*) All parents have similar tastes for schooling, but wealthier parents buy more of it like they do other normal goods. (*c*) Wealthier parents have a stronger preference for schooling than poor parents. Notably, these explanations mirror the earlier discussion of the wealth–schooling relationship, only for parents rather than for students themselves.

Whereas the results of Keane & Wolpin (2001) and Johnson (2011) suggest that expansions in student loan programs are likely to have limited effects on college-going, they effectively shift the constrained question up a generation. It is not clear how these results help explain the dramatic increase in family income–attendance gaps over the past few decades. Efforts to endogenize parental transfer decisions would help in answering this question.

Adolescent endowments or abilities also play a central role in determining the relationship between socioeconomic background and education (and earnings) outcomes in both Keane & Wolpin (2001) and Johnson (2011). This is also true in studies explicitly analyzing education gaps by family income (e.g., Cameron & Heckman 1998, Carneiro & Heckman 2002, Belley & Lochner 2007). Yet these endowments are typically treated as exogenous and invariant to policy. Recent work discussed in Section 4 endogenizes these endowments through early investments by families and schools.

Finally, the empirical literature on borrowing constraints and education is almost exclusively partial equilibrium. Heckman et al. (1998) and Gallipoli et al. (2011) show that incorporating general equilibrium effects on skill prices can considerably dampen the impacts of education policies on schooling. We discuss macro-based general equilibrium studies in Section 5.

3.4. Other Approaches to Identifying Constraints

Stinebrickner & Stinebrickner (2008) take a novel approach to measuring borrowing constraints by directly asking students enrolled at Berea College in Kentucky whether they would like to borrow more if they could (at a "fair" interest rate). It is important to note that the typical student at Berea College comes from a low-income family; however, the college is unique in that it effectively charges zero tuition and offers large room-and-board subsidies. Despite these unique institutional features, college dropout rates are similar to those for low-income students in the United States as a whole. Although Stinebrickner & Stinebrickner (2008) find that many Berea students live on a tight budget, only about one in five reports that they would like to borrow more if they could (i.e., constrained). They further estimate that college dropout rates (by the beginning of year two) are approximately 13 percentage points higher (or roughly double) for constrained youth relative to those that are unconstrained. Adjusting for other potential determinants of dropout reduces this difference to approximately 11 percentage points.

Brown et al. (2011) explicitly model intergenerational relationships and derive a new way of identifying which youth may be affected by borrowing constraints. Their model assumes that youth would be borrowing constrained if they did not receive help from their parents; however, this assumption could be relaxed without changing the spirit of the results. Parents are assumed to be able to borrow freely, but they cannot write enforceable loan contracts with their children. As a result, they may not want to transfer enough resources to satisfy their children's demand for consumption and schooling at college ages. In this case, parents would provide all their transfers to their children when they were college age, but children would underinvest. By contrast, unconstrained families will transfer enough resources to their children to support optimal investment, continuing to make transfers after their children leave school. These results suggest that one can distinguish between constrained and unconstrained families based on the presence of postschool parental transfers. Brown et al. show that in their framework, total human capital investment should be more sensitive to a tuition subsidy among constrained youth than among unconstrained youth.[21]

Based on these insights, Brown et al. use intergenerational data on educational attainment and family transfers from the Health and Retirement Survey (HRS) to estimate the effects of borrowing constraints on schooling in the United States during the 1970s, 1980s, and 1990s. They identify constrained youth as those receiving no postschool family transfers.[22] Because the HRS does not contain information on educational subsidies/aid, they use sibling spacing as an instrument for student aid. Families with multiple children in college at the same time generally qualify for more aid than families with children attending at different times. Their estimates suggest that among constrained youth, an additional $3,600 in aid (i.e., four versus zero years of sibling overlap in college) increases average schooling by 0.2 years. The estimated effects of additional aid on unconstrained youth are negligible.

3.5. Summarizing the Evidence

Most studies analyzing the NLSY79 data find little evidence that borrowing constraints affected college-going in the early 1980s. Significant increases in the share of students maxing out their federal student loan opportunities and a doubling in family income–college attendance gradients for recent cohorts suggest that constraints have become more salient in recent years. Because differences in parental transfers and the degree of labor

[21]As Carneiro & Heckman (2002) discuss, this result does not necessarily generalize to other models.

[22]For their main sample, they measure transfers during 1998, 2000, 2002, and 2004. A supplementary sample measures substantial transfers prior to 1994. End-of-life bequests are not included.

market risk are also important factors in explaining income–attendance patterns, the literature has yet to reach a consensus on the extent to which constraints discourage youth for recent cohorts.

Borrowing constraints may affect more than college attendance. For example, family income has become a more important determinant of attendance at four-year (relative to two-year) schools, whereas it has become less important for attendance at very selective institutions. Borrowing constraints could also delay college attendance, but the evidence reveals little impact on this margin. Instead, constrained students appear to work more and consume less while in school than those that are unconstrained.

4. EARLY INVESTMENTS IN CHILDREN

There is strong evidence that adolescent skill levels are important in determining subsequent schooling and lifetime earnings (see, e.g., Cameron & Heckman 1998; Keane & Wolpin 1997, 2001; Carneiro & Heckman 2002). Moreover, evidence from consumption allocations suggests that liquidity constraints are most salient for younger households (e.g., Meghir & Weber 1996, Alessie et al. 1997, Stephens 2008). Yet few studies examine the impacts of borrowing constraints on early investments in young children.

Indirect evidence suggests that constraints at early ages may play a more important role in determining human capital investment than constraints at later ages. For example, most empirical studies find high lifetime returns for early childhood programs, especially for the most disadvantaged children (e.g., see Karoly et al. 1998, Blau & Currie 2006, Cunha et al. 2006, Heckman 2010). A few studies also find that family income received at early childhood ages has a greater impact on achievement and educational attainment when compared with income received at later ages (e.g., Duncan & Brooks-Gunn 1997; Duncan et al. 1998; Levy & Duncan 1999; Caucutt & Lochner 2006, 2011).[23] More generally, recent studies show that exogenous increases in family income lead to improvements in early child development (see, e.g., Akee et al. 2010, Løken 2010, Løken et al. 2010, Duncan et al. 2011, Milligan & Stabile 2011, Dahl & Lochner 2012).

Credit constraints are natural candidates to explain why most low-income children do not participate in quality preschool programs despite the high economic returns. Even though elementary and secondary education is publicly provided, the quality of public schools available to poor American families is often low, whereas high-quality private schools and preschool programs are typically quite expensive. Parental time is also a valuable input that poor parents may be unable to afford. Finally, most parents of young children are young themselves, in the early stages of their careers with relatively low earnings.

To better understand the role of borrowing constraints at early childhood and adolescent ages, it is useful to generalize the human capital production function in Section 2 to include multiple periods of investment. To focus on intertemporal issues related to borrowing constraints, we abstract from allocation decisions across different inputs within

[23] Carneiro & Heckman (2002) argue that early income should have a larger effect than later income owing purely to discounting [e.g., \$1 at age 0 should have an effect that is $(1+r)^{10}$ larger than income at age 10, where r is the annual interest rate]. Accounting for this, they estimate similar effects of early and late family income on college enrollment in the Children of the NLSY (CNLSY); however, they also control for age 12 achievement levels, which may absorb much of the effect of earlier income. Caucutt & Lochner (2006, 2011) estimate that (discounted) income received at earlier ages has a larger impact on age 5–14 cognitive achievement and educational attainment in the CNLSY than (discounted) income received at later ages.

periods (e.g., parental time versus schools versus family goods inputs).[24] For simplicity, suppose human capital upon labor market entry H depends on early childhood investment h_1, adolescent investment h_2, and ability a:

$$H = af(h_1, h_2). \tag{8}$$

As discussed in Cunha et al. (2006) and Cunha & Heckman (2007), the dynamic complementarity between early and late investments (as measured by $\frac{\partial^2 f}{\partial h_1 \partial h_2}$ or the elasticity of substitution) is crucial for the accumulation of human capital over the life cycle. With strong complementarity, it is difficult to compensate for a lack of early investment at later ages. In this case, inadequate early investments lead to low returns for later investments, consistent with evidence in Keane & Wolpin (2001) and Cameron & Heckman (1998).

The estimates of Cunha et al. (2010) suggest that investments are quite complementary over time, with the degree of dynamic complementarity growing with age for cognitive skills.[25] They find that it is optimal to invest relatively more in young children with investment declining with age. This is particularly true for children with low initial endowments. An optimal path of declining investment contrasts sharply with the typical pattern of increasing parental earnings over the life cycle. To the extent that borrowing constraints limit early investments in some children, those early deficits are likely to be compounded over time.

Two recent studies consider the importance of dynamic complementarity in investments over the life cycle when financial markets are imperfect.[26] Cunha (2007) estimates a similar life-cycle human capital production technology to that of Cunha et al. (2010) and embeds it in a Laitner (1992) overlapping-generations general equilibrium model. In this model, individuals never borrow up to the natural limit, but there are no explicit constraints on life-cycle borrowing. Parents cannot leave negative transfers to their children, however. Caucutt & Lochner (2011) develop and calibrate a similar dynastic overlapping-generations model; however, they incorporate age-specific borrowing constraints. Focusing on early versus late investments, they consider a six-period model of the life cycle, with late investments corresponding to different levels of educational attainment.[27]

Caucutt & Lochner find that many young and middle-age parents are borrowing constrained, including some with higher education. However, like Keane & Wolpin (2001) and Johnson (2011), their model suggests that there would be little impact on human capital investment (early or late) from relaxing borrowing constraints on college-age youth or their parents. By contrast, relaxing constraints on young parents would lead to sizeable short-run increases in both early investments in young children and late investments in older children

[24] Del Boca et al. (2010), Todd & Wolpin (2003, 2007) and Cunha et al. (2010) analyze child development when there are multiple inputs each period.

[25] Cunha et al. (2010) estimate elasticities of substitution ranging from 0.4 to 1.5. They use data from the CNLSY and exploit a dynamic nonlinear factor structure and multiple measurements for cognitive and noncognitive skills and family investments.

[26] Del Boca et al. (2010) estimate the productivity of both time and goods inputs over childhood; however, they abstract from borrowing and saving altogether and focus primarily on within-period investment choices. Restuccia & Urrutia (2004) calibrate a dynastic equilibrium model of human capital production with early and late investments; however, they also abstract from borrowing and saving and make strong assumptions about the interaction of investments over time. We discuss Restuccia & Urrutia in Section 5.

[27] Both Cunha (2007) and Caucutt & Lochner (2011) identify a similar degree of complementarity between early and late human capital investment to that estimated by Cunha et al. (2010).

(e.g., high school completion and college). The long-run effects of such a policy are quite different. Because relaxing the borrowing constraint for young parents causes families to accumulate more debt over time, future generations find themselves constrained to nearly the same extent that initial generations were before the constraint was relaxed. On average, this shift in assets results in negligible long-run effects on average human capital levels.

Simulations by both Cunha (2007) and Caucutt & Lochner (2011) suggest that subsidies for early investment produce much greater gains in human capital than (fiscally equivalent) subsidies for late investment. Dynamic complementarity implies that families with few resources when their children are young do not fully capitalize on subsidies at later ages because it is too costly to adjust early investments. Those that receive inadequate early investments do not find it worthwhile to make additional later investments (especially college) even if they are heavily subsidized. By contrast, early investment subsidies enable families to increase investments in their young children without sacrificing current consumption or borrowing more. Those investments can then be matched with later investments when constraints are less severe.

Dynamic complementarity also implies that college-age subsidies lead to increases in earlier investments and adolescent skill levels, effects neglected in most analyses of higher education policy. Caucutt & Lochner (2011) show that ignoring early investment responses would cause researchers to significantly underestimate policy impacts on college attendance as well as future wage levels.

5. MACROECONOMIC PERSPECTIVES

Human capital has received wide attention in the literature on cross-country income differences (see, e.g., Mankiw et al. 1992, Klenow & Rodriguez-Clare 1997, Hall & Jones 1999). Yet less attention has been given to the role of the different factors, including credit constraints, that explain cross-country human capital differences (however, see Bils & Klenow 2000, Kaboski 2007, Manuelli & Seshadri 2010). We now review the literature on the macroeconomic consequences of credit market imperfections, including the impact on social (intergenerational) mobility, the overall distribution of skills, and income and the effect of government policies.

5.1. Aggregate Schooling and Income

Credit constraints can be a key determinant of aggregate human capital. Recent work by Cordoba & Ripoll (2011) shows that introducing credit constraints significantly improves the ability of a Ben-Porath-type model to explain cross-country variation in the average years of schooling and the gap between returns to schooling and returns on riskless financial assets (Ben-Porath 1967). In a frictionless model, aggregate human capital investments are entirely determined by the life span of individuals in a country, the country's total factor productivity (TFP), and tax policies. Cordoba & Ripoll show that credit constraints can also add parental lifetime income, family size, and the supply of public education as determinants of education investments. By incorporating these factors, their model better explains observed cross-country differences in human capital stocks.

Aside from effects on aggregate investment levels, credit constraints could reduce the efficiency of investment in human capital by diverting education from the most-able youth from poor families toward less-able youth from wealthier families. Empirically, this distortion could show up in a country's schooling sector TFP (as in Caucutt & Kumar 2003) or in its TFP for consumption goods (as in Benabou 2003). Understanding these mechanisms requires models in which the distribution of income is endogenously determined by preferences and market opportunities. We briefly review this literature next.

5.2. Inequality and Persistence of Skills and Income

Becker & Tomes (1979, 1986) and Loury (1981) pioneered the development of fully consistent economic models of income distribution based on intergenerational transfers and investments in human capital. In these models, human capital for generation *t* depends on the investments and ability for that generation. It may also depend on shocks to the production of human capital as well as the human capital of one's parents. Ability is typically assumed to follow a first-order Markov process across generations, and earnings generally depend on human capital levels, independent idiosyncratic market shocks, and the economy-wide price of human capital. Credit constraints also limit the capacity of poor parents to invest in their children.

In terms of preferences, the standard assumption is that of "altruistic" preferences, when parents directly value their children's welfare (see, e.g., Loury 1981, Becker & Tomes 1986, Benabou 2003). Other, simpler forms of preferences are also sometimes used. "Paternalistic" preferences assume that parents directly value human capital investments or outcomes, or even earnings (see, e.g., Glomm & Ravikumar 1992, Fernandez & Rogerson 1998). Finally, "warm-glow" preferences assume that parents directly value transfers/bequests to their children, not caring what children do with the money (see, e.g., Galor & Zeira 1993, De Nardi 2004). The form of intergenerational preferences can have important consequences.

The pioneering work by Becker & Tomes (1979) and Loury (1981) assumes that all human capital is in the form of parental investments in their children. Both analyses rule out financial transfers and derive conditions for the economy to converge to a unique invariant income (and skill) distribution from any initial conditions. In both cases, the economy is ergodic in the sense that the impact of initial conditions for a dynasty progressively washes out with the passing of time and generations. The asymptotic distribution of (relative) incomes for any dynasty (across generations) is exactly the same as the cross-sectional distribution for the economy as a whole. Regression to the mean arises because richer (poorer) than average parents tend to have richer (poorer) than average children, but the gaps tend to close over time.

In Loury (1981), parents are altruistic, and a positive intergenerational persistence in income arises even when ability is not correlated across generations. Incomplete markets are important to generate social mobility; otherwise, if parents could fully insure against the ability of their offspring, the relative wealth of different dynasties would never change. Alternatively, with paternalistic preferences, Becker & Tomes (1979) show how social mobility is driven by intergenerational persistence in ability, the variance of labor market shocks, and the extent to which parents value the income of their children.

Becker & Tomes (1986) extend their earlier analysis, incorporating ability-investment complementarity, nonnegative parent-to-child financial transfers, and altruistic preferences. Constrained families leave zero financial bequests and underinvest in their children, even if their entire parental transfer is in human capital. Interestingly, their model suggests that the relationship between ability and investment might be negative for constrained families, as discussed in Section 2.1.

The form of human capital investment technology can be crucial for the behavior of aggregate economies. For instance, Galor & Zeira (1993) introduce indivisibilities in human capital investment: Individuals either attend or do not attend college. In the presence of credit market imperfections (modeled as a positive gap between borrowing and lending interest rates), Galor & Zeira show that nonconvexities in investment can lead to multiple steady states and hence can explain persistent differences in per-capita output across countries. Their steady states fall into three categories: (*a*) global poverty traps (the entire population is unschooled); (*b*) a perfect caste system with an individual poverty trap in which some dynasties are forever unschooled, whereas the others are forever schooled; and (*c*) a fully developed country/skilled population equilibrium. Which steady states arise depends entirely on the initial distribution of wealth and skills, a sharp contrast with the ergodicity in Loury (1981) and Becker & Tomes (1979).[28] The key for these differences in aggregate investments and social mobility is nonconvexity in schooling choices, not the form of preferences. Indeed, Caucutt & Kumar (2003) find similar results with altruistic preferences.

Aiyagari et al. (2002) and Caucutt & Kumar (2003) develop early quantitative frameworks to study the formation of human capital and the evolution of earnings across generations. Aiyagari et al. (2002) compare economies with full and partial altruism and economies with incomplete insurance markets. They show that credit constraints and lack of insurance do not necessarily lead to underinvestment; indeed, they can lead to overinvestment. However, investment is generally inefficient, as it is not necessarily directed toward the most-able children.

Caucutt & Kumar (2003) assume altruistic preferences and lumpy human capital investments with uncertain payoffs (i.e., students may fail to complete school). As in most of this literature, Caucutt & Kumar rule out financial investments/transfers and assume that families cannot insure against the different risks they face, including the possibility of school failure (which depends on ability) and uncertainty in the ability levels of grandchildren and subsequent generations. To fit intergenerational schooling relationships in the data, they introduce an additional form of intergenerational persistence, namely that parental education directly enters the probability that children successfully complete college. Their preferred calibration captures the share of college-educated workers, the college wage premium, and the enrollment and dropout rates of children conditional on parental education as observed in the United States.

Restuccia & Urrutia (2004) extend the dynastic framework of Caucutt & Kumar (2003) to include a period of early investment in children along with a college-attendance decision at later ages. Early investments (and innate abilities) are assumed to increase earnings associated with college attendance as well as the likelihood of finishing college. Borrowing and saving, as well as intergenerational financial transfers, are ruled out. Calibrating their model to US data, they argue that differences in early investments by

[28]The lack of ergodicity is likely to hold even with ability shocks, as long as abilities are always high enough so that rich individuals always find it worthwhile to invest in college. One way to induce ergodicity is to introduce large (and uninsured) postinvestment income shocks that consistently move dynasties away from the attraction of unschooled and schooled resting points. If so, unschooled rich (impoverished, poor) parents may (not) transfer enough resources for the child to go to school.

parental income are largely responsible for observed levels of intergenerational persistence, as the lack of credit availability is particularly problematic for poor young parents (for reasons discussed previously in Section 4).

Gallipoli et al. (2011) incorporate schooling in a life-cycle model with consumption and labor supply decisions. Individuals face debt limits and a wedge between borrowing and lending interest rates. The framework allows for heterogeneity in ability and a rich structure of productivity shocks. This problem is embedded in a dynastic general equilibrium environment with imperfect substitutability between the human capital of different schooling types. Their model explains schooling patterns as well as cross-sectional and life-cycle earnings, consumption, and labor supply behavior in the United States.

5.3. Government Policies

When credit constraints limit the ability of younger generations to invest in human capital, private market allocations can be inefficient, and government-enforced transfers from older to younger generations may increase overall efficiency. In many cases, those transfers may not be politically implementable because they entail losses for older generations.[29] However, as argued by Boldrin & Montes (2004), intergenerational conflict can be averted—and efficiency restored—if public schooling policies are tied to other government transfers. Although they consider a stylized environment with three homogeneous generations and exogenous constraints, their logic provides a useful reference point for three key limitations in the design of government policies: (*a*) heterogeneity, (*b*) the endogeneity of private credit constraints, and (*c*) risks and incentive problems.

Heterogeneity in abilities and family resources can be a major limitation for the efficacy of government programs. Benabou (2003) considers progressive income taxation and education subsidies in economies with heterogeneous agents and characterizes the trade-offs between efficiency (and growth) and insurance. In practice, many government programs attempt to cope with heterogeneity, offering differential treatment in terms of ability (merit-based) or in terms of resources (need-based). However, merit-based programs may be imprecise in differentiating by ability, especially at younger ages when investments may have high returns and credit constraints may be most severe. Need-based programs may be more precisely targeted, but they can lead to inefficient overinvestment by lower-ability individuals.[30]

Caucutt & Kumar (2003) and Gallipoli et al. (2011) consider the impacts of different education policies paid for with proportional income taxes. In both frameworks, need-based subsidies help alleviate borrowing constraints, but they also encourage some low-ability poor youth to overinvest. Taxes required to finance subsidies and a reduction in the wage premium for educated workers dampen schooling responses in general equilibrium. Overall, welfare and aggregate productivity gains from increases in current aid levels are found to be quite small. Caucutt & Kumar (2003) further find that a combined need- and

[29]This presumes that resources in education are used efficiently. If not, then improvements in the efficiency of schooling may be achieved without requiring intergenerational transfers. Alternatively, it may be feasible for older generations to capitalize on the returns from investment in the young, a possibility ruled out by the simple structure of Boldrin & Montes (2004).

[30]The regional scope of public schooling can be another limitation for merit- and need-based policies. As individuals sort across regions of different incomes, the quality of schooling could greatly differ across youth of similar ability but different family resources (see Glomm & Ravikumar 1992, Fernandez & Rogerson 1998).

merit-based subsidy does no better in terms of welfare than a simple need-based subsidy. Gallipoli et al. (2011) find similar efficiency gains (to need-based subsidies) for a policy that both increases student loan limits and reduces borrowing interest rates.

Enriching the analysis with early investments significantly changes the implications for government policies. Restuccia & Urrutia (2004) find that increasing government funding for early schooling substantially increases social mobility, aggregate human capital, consumption, and output. By contrast, increasing subsidies to college (late) education has negligible effects on social mobility and produces smaller increases in aggregate human capital, output, and consumption. Although this policy increases college enrollment rates, it also increases college failure rates, reducing the efficiency of the college sector.

The incorporation of early investment endogenizes the formation of—and heterogeneity in—ability, effectively moving the model closer to one with homogeneous agents as in Boldrin & Montes (2004). Indeed, Restuccia & Urrutia (2004) report that calibrating their model without early education requires a much greater exogenous dispersion in innate abilities to fit the data.

Another major consideration typically neglected in analyses of government policies is the endogenous response of private market arrangements. As stressed in the next section, credit constraints arise from repayment incentive problems and institutional features of the economy. These incentive problems are affected by taxes and subsidies that governments impose on the different actions and outcomes of individuals. For example, Andolfatto & Gervais (2006) show that when credit constraints are endogenously driven by limited commitment, transfers to the young and old (from middle-age workers) could reduce the supply of resources for youth to invest in human capital, as default incentives induce private lenders to reduce student credit by more than the youth transfer amount.[31]

Finally, the risky nature of human capital can give rise to many incentive problems, including imperfect observability and moral hazard during and after school. Much of the research on human capital has yet to incorporate lessons from the literature on optimal contracts with dynamic incentive problems. We discuss some of these issues in Section 6.

5.4. Cross-Country Variation in Access to Credit

The literature is silent about cross-country differences in access to credit; however, there is evidence of significant cross-country dispersion in the effect of household wealth on educational attainment in developing countries (e.g., Filmer & Pritchett 1999). To capture these differences, one could try to measure and account for differences in the levels of credit in each country (e.g., as in Buera et al. 2011 for firm external financing). Taking this further, one could endogenize credit constraints based on institutions and policies in each country. These unexplored avenues could lead to new insights on differences in human capital accumulation across countries and the impact of different government policies.

6. THE NATURE OF BORROWING CONSTRAINTS FOR EDUCATION

Despite extensive interest in the impact of credit constraints on the market for human capital, little attention has been paid to the underlying institutions and incentive problems

[31]Wang (2011) further examines the conditions under which full efficiency can be restored with endogenous credit constraints.

limiting the access to credit for young individuals with little collateral to pledge. Instead, nearly all theoretical and empirical work assumes ad hoc limits on borrowing (as in Section 2) or arbitrary differences in interest rates based on family income. These simple assumptions are at odds with the actual operation of public and private sources of credit for education.

This section shows that more realistic assumptions about government and private lending can be useful for understanding the behavior of human capital investments. We begin by discussing individual behavior when future incomes are certain and then introduce uncertainty about returns to human capital.

6.1. Government Student Loans and Limited Commitment

Many students turn to GSL programs and private lenders to help finance tuition and living costs while enrolled in college.[32] GSL programs explicitly link credit to educational expenditures, whereas private lenders extend credit to students based on their prospects of repayment and projected future earnings. We now describe the constraints implied by central features of existing GSL programs and private lending within the context of the two-period model of Section 2.1.

6.1.1. Government student loan programs. Lending programs supported by the federal US government generally have three salient features. First, lending is directly tied to investment. Students (or parents) can only borrow up to the total cost of college (including tuition, room, board, books, and other expenses directly related to schooling) less any other financial aid they receive in the form of grants or scholarships. Thus GSL programs do not finance nonschooling-related consumption expenses. Second, GSL programs set upper loan limits on the total amount of credit available for each student. Stafford and Perkins Loans are subject to both annual and lifetime limits.[33] Third, GSL programs typically have extended mechanisms to enforce repayment as compared with unsecured private loans. For example, student loans cannot be expunged through bankruptcy; tax offsets and wage garnishments can be used to collect amounts owed.[34]

The first two features of GSL programs imply that government borrowing d_g must satisfy

$$d_g \leq \min\left\{\tau h, \bar{d}\right\}. \tag{9}$$

The upper limit $\bar{d}$ is specified by law as part of GSL programs. Given their strong enforcement, assume for now that government loans must be repaid. In Section 6.2, we consider more general models with default.[35]

[32]Low-income families are targeted by federal and state aid (e.g., Pell Grants) to finance the cost of college. Moreover, private and public institutions supplement these funds with their own grant aid. However, for many students, there remains a gap between the cost of college and the resources available from grants and their families (see Belley et al. 2011 for a detailed description of need-based aid).

[33]From 1993 to 2007, undergraduate annual Stafford Loan limits for dependent students ranged from \$2,625 (year one) to \$4,000 (years three to five) with a cumulative total of \$23,000. Graduate students could borrow \$18,500 per year, accumulating up to \$138,500 in Stafford Loan debt.

[34]Readers are referred to Ionescu (2008, 2009, 2011) and Lochner & Monge-Naranjo (2011b) for more detailed descriptions of GSL programs.

[35]In practice, default rates have hovered around 5%–10% over the past 15 years.

6.1.2. Private lending. The importance of private lending markets for schooling has skyrocketed from virtually zero in the early 1990s to over $15 billion in 2005–2006, which is 20% of all student loan dollars distributed (College Board 2006). Credit cards have also become an important source of funds for students (Nellie Mae Corp. 2005).

In modeling private lending, it is useful to derive credit constraints that arise endogenously when lenders have limited mechanisms for enforcing repayment (e.g., Andolfatto & Gervais 2006, Lochner & Monge-Naranjo 2011b).[36] A rational borrower repays private loans if and only if repaying is less costly than defaulting. These limited incentives can be foreseen by rational lenders who, in response, limit their supply of credit to amounts that will be repaid.[37] Because penalties for default typically impose a larger monetary cost on borrowers with higher earnings and assets, credit offered to an individual is directly related to his perceived future earnings. Because expected earnings are determined by ability and investment, private credit limits and investments are codetermined in equilibrium.

Assume that the cost of default on private loans is equal to a fraction $0 < \tilde{\kappa} < 1$ of labor earnings.[38] Then borrowers repay if and only if the payment Rd_p is less than the punishment cost $\tilde{\kappa}af(h)$. As a result, credit from private lenders is limited to a fraction of postschool earnings

$$d_p \leq \tilde{\kappa}R^{-1}af(h) \tag{10}$$

and is increasing in both ability and investment. Ability also indirectly affects credit through its influence on investment.

Total borrowing d of a student that can borrow d_g from the GSL, subject to Equation 9, and d_p from private lenders, subject to Equation 10, is constrained by

$$d = d_g + d_p \leq \min\{\tau h, \bar{d}\} + \tilde{\kappa}R^{-1}af(h). \tag{11}$$

Assuming GSL repayments are fully enforced, government credit does not crowd out private credit. Lochner & Monge-Naranjo (2011b) show that a similar constraint holds in a life-cycle model that includes both temporary exclusion from credit markets and wage garnishments as punishments for default. However, in that model partial crowd out arises even if GSL credit is fully enforceable. In general, some crowding out is expected to arise because of lower incentives to repay private debt.

6.1.3. Empirical implications. Lochner & Monge-Naranjo (2011b) show that this form of endogenous credit constraint can explain a number of patterns observed in higher education as the equilibrium responses to the increased returns to and costs of college observed since the early 1980s, given stable GSL limits. Their quantitative analysis suggests that in the early 1980s, GSLs provided adequate credit to most students, and only a few would have needed private funding. College attendance was, therefore, largely independent of family resources. The rising college costs and returns over time have encouraged more recent cohorts to invest and borrow more, with those exhausting GSL credit choosing

[36]Indeed, limited repayment enforcement is the central justification for assuming credit market imperfections in the education sector (Becker 1967).

[37]Gropp et al. (1997) empirically support this form of response by private lenders.

[38]This is consistent with wage garnishments and costly penalty-avoidance actions like relocating, working in the informal economy, borrowing from loan sharks, or renting instead of buying a home.

to borrow from private lenders. Private lenders have responded by endogenously raising their credit limits, although not enough to ensure efficient investment for everyone.

Another implication is that some of the distortionary effects of credit constraints is shifted onto consumption and away from investment. This prediction arises from the link of GSL and private credit to investment and is consistent with the findings of Keane & Wolpin (2001), Stinebrickner & Stinebrickner (2008), and Johnson (2011). Indeed, Lochner & Monge-Naranjo show that constrained individuals may not underinvest at all, as additional investments (at the margin) can be financed with additional government or private loans. The endogenous nature of private and GSL credit also accommodates greater investment among the most able because total credit is increasing in both investment and ability. In general, constrained investment is more likely to be increasing in ability than when credit limits are exogenous (Lochner & Monge-Naranjo 2011b).

A framework with endogenous credit constraints is useful for studying the interaction between private credit and GSL programs and other government policies. Simulations by Lochner & Monge-Naranjo suggest that expansions of public credit have only modest crowd-out effects on private lending. Increases in GSL limits lead to higher levels of total credit and raise human capital investment among constrained youth. Additionally, changes in GSL credit tend to have a relatively greater impact on investment among the least able, whereas changes in private loan enforcement tend to impact investment more among the most able. Finally, endogenous borrowing constraints make human capital investment more sensitive to government education subsidies. Policies that encourage investment are met with enhanced access to credit, further encouraging investment. This credit-expansion effect, absent when constraints are fixed, can be quite large.

6.2. Uncertainty, Default, and Other Incentive Problems

To capture other important incentive problems, we now introduce risky returns and discuss the implications of imperfect insurance and private information for the provision of credit and human capital investment. The incorporation of ideas from the literatures on optimal contracting with limited commitment, private information, and moral hazard can be helpful for understanding schooling, borrowing, and repayment decisions. It also offers useful guidance in designing efficient policies to provide both credit and insurance for schooling in a risky environment.

For simplicity, we abstract from forgone wages and normalize tuition costs to 1 (i.e., $w_0 = 0$ and $\tau = 1$). Assume now that the second-period price of human capital is stochastic and can take on $i = 1, \ldots, N$ possible realizations. Let $p_i > 0$ denote the probability of realization $w_{1,i}$, which we order so that $w_{1,1} < w_{1,2} < \ldots < w_{1,N}$. Assume that the individual and potential lenders observe the true probabilities as well as individual ability a and initial assets W.[39] Individuals maximize expected utility

$$U = u(c_0) + \beta \sum_{i=1}^{N} p_i u(c_{1,i}),$$

where $c_{1,i}$ is second-period consumption associated with realization i.

[39]Here uncertainty in $w_{1,i}$ could also reflect uncertainty in ability; however, we abstract from learning about ability while in school as in Stinebrickner & Stinebrickner (2012).

Let D_i be the (possibly negative) quantity that a person commits to repay in the second period, potentially contingent on the realization i. Budget constraints are

$$c_0 = W - h + \sum_{i=1}^{N} q_i D_i,$$
$$c_{1,i} = af(h)w_{1,i} - D_i, \quad i = 1, \ldots, N.$$

Here q_i is the (Arrow) price of a contingent claim that pays 1 if realization i takes place and zero otherwise. For cases with complete markets, we follow the standard assumption of risk-neutral, arbitrage-free asset prices, i.e., $q_i = \beta p_i$.

6.2.1. Unrestricted optima. With complete markets, human capital investments $h^U(a)$ maximize the expected net present value of lifetime income by equating the marginal cost of investing with the expected marginal return:

$$\bar{w}_1 af'\left[h^U(a)\right] = \beta^{-1},$$

where $\bar{w}_1 \equiv \sum_{i=1}^{N} p_i w_{1,i}$ is the expected period 1 price of skill. Neither preferences nor initial wealth W has an effect on investment because there are no restrictions on asset/debt holdings and there is full insurance. Asset/debt holdings D_i are set to optimally smooth consumption over time and across states: $u'(c_0) = u'(c_{1,i})$, for all $i = 1, \ldots, N$.

6.2.2. Limited commitment with complete markets. To introduce limited commitment, assume that individuals can default on their debts in the second period. Doing so, they attain a default utility of $V^D(w_{1,i}, a, h)$, which would generally be increasing in the realization $w_{1,i}$, ability a, and human capital investments h. The option to default gives rise to the participation constraint $u\left[w_{1,i}af(h) - D_i\right] \geq V^D(w_{1,i}, a, h)$, which limits the credit and insurance of borrowers.

Letting $\lambda_i \geq 0$ denote the (discounted) multiplier on participation constraint $i = 1, \ldots, N$, optimal debt holdings satisfy $u'(c_0) = (1 + \lambda_i)u'(c_{1,i})$. For states $w_{1,i}$ in which the participation constraint does not bind ($\lambda_i = 0$), there is perfect consumption smoothing, $c_{1,i} = c_0$. However, if either a is high or W is low, the participation constraint may bind for some states, in which case we should observe positive consumption growth, $c_{1,i} > c_0$.

To explore the implications for human capital accumulation, we now focus exclusively on the case in which a borrower who defaults is penalized by forfeiting a fraction $\tilde{\kappa} \in [0,1]$ of her earnings. This implies $V^D(w_{1,i}, a, h) = u[(1 - \tilde{\kappa})w_{1,i}af(h)]$, so participation constraints reduce to simple solvency constraints of the form $D_i \leq \tilde{\kappa}w_{1,i}af(h)$ for all $i = 1, \ldots, N$. To ensure repayment, the debts carried into any state cannot exceed the income forfeiture. Solvency constraints bind for high realizations of $w_{1,i}$, in which case repayments equal $D_i = \tilde{\kappa}w_{1,i}af'(h)$. There is perfect smoothing across low-earnings states but only limited insurance in high-earnings states.[40] Optimal human capital investment $h^{LC}(a, W)$ satisfies

$$\bar{w}_1 af'\left[h^{LC}(a, W)\right]\left[\frac{\sum_{i=1}^{N} p_i w_{1,i}\left(\frac{1+\lambda_i\tilde{\kappa}}{1+\lambda_i}\right)}{\bar{w}_1}\right] = \beta^{-1}.$$

[40]Compared with a simple income-contingent repayment scheme in which individuals always repay a constant fraction of their income, these allocations provide greater insurance in low-income states.

When all $\lambda_i = 0$, the unrestricted allocation is attained. Whenever at least one solvency constraint binds, investment is lower than the unrestricted level. This is because $\sum_{i=1}^{N} p_i w_{1,i}\left(\frac{1+\lambda_i\tilde{\kappa}}{1+\lambda_i}\right) < \bar{w}_1$ when $0 < \tilde{\kappa} < 1$ and $\lambda_i > 0$ for some i.

Other implications for investment are also similar to those discussed above in the model of Section 6.1 with perfect certainty. For example, human capital investments help relax solvency constraints in both models. This encourages investment and implies a credit-expansion response to education policies, as discussed above. Furthermore, default does not occur in equilibrium because all debt repayments are contingent on future states. With such rich contracts, optimal institutional arrangements would minimize the temptation of default by raising $\tilde{\kappa}$ as high as possible ($\tilde{\kappa} = 1$), in which case the economy attains the unconstrained optimal allocation.

6.2.3. Limited commitment with incomplete markets. We now take the opposite extreme from fully contingent contracts and assume that second-period liabilities cannot depend on the state, $w_{1,i}$. Owing to the incompleteness of contracts, default may now occur in equilibrium. We assume that punishments for default take the same form of a proportional income forfeiture $\tilde{\kappa} w_{1,i} a f(h)$, which is recovered by lenders.

Let $D > 0$ be the amount of debt individuals promise to repay after school. Of course, individuals will actually repay if and only if $D \leq \tilde{\kappa} w_{1,i} a f(h)$. This defines the threshold for $w_{1,i}$, $\tilde{w}_1(D, a, h) \equiv \frac{D}{\tilde{\kappa} a f(h)}$, below which an individual defaults. The probability of default, $\Pr\left[w_{1,i} < \tilde{w}_1(D, a, h)\right]$, is weakly increasing in the level of debt D and decreasing in ability a and human capital h. In exchange for a promised payment $D > 0$, risk-neutral lenders would be willing to extend credit in an amount equal to

$$Q(D, a, h) = \beta\left\{D - \sum_{w_{1,i}<\tilde{w}_1} p_i\left[D - \tilde{\kappa} w_{1,i} a f(h)\right]\right\}.$$

From the full repayment D, this expression subtracts the expected losses $D - \tilde{\kappa} w_{1,i} a f(h)$ from defaulting loans. Expected payments, $Q(D, a, h)$, are not monotonically increasing in debt, as increasing debt can more than proportionally reduce the probability of repayment.[41] A hard borrowing constraint is given by $\sup_D\{Q(D, a, h)\} < \infty$, the maximum value a lender could possibly expect to extract from someone with ability a investing h.

For simplicity, assume that $\tilde{w}_1$ falls outside the support of $w_{1,i}$ and therefore ignore jumps in the default probabilities (see Lochner & Monge-Naranjo 2011a for a complete analysis of the general case). Under this assumption, marginal changes in D and h do not affect the probability of default, and the necessary first-order condition for D is

$$u'(c_0) = E\left[u'(c_{1,i})\,|\,w_{1,i} \geq \tilde{w}_1\right].$$

Optimal borrowing trades off the gains in consumption c_0 with the costs on future consumption only in higher-income states of the world in which there is repayment. The necessary condition for optimal h is

$$\bar{w}_1 a f'(h)\left[\frac{\sum_{i=1}^{N} p_i u'(c_{1,i}) w_{1,i} - \tilde{\kappa}\sum_{w_{1,i}<\tilde{w}_1} p_i u'(c_{1,i}) w_{1,i}}{\bar{w}_1 u'(c_0)(1 - Q_h)}\right] = \beta^{-1},$$

[41]As a function of D, only the increasing region of $Q(\cdot, a, h)$ is relevant.

where $Q_h > 0$ is the partial derivative (subgradient) of Q with respect to h and must be strictly less than 1 at the optimum.[42] This equation reveals three important differences between investment here and under full insurance. First, additional investment increases expected payments, thereby expanding credit. This credit-expansion effect encourages investment. Second, some benefits of investment are lost in the event of default because $0 < \tilde{\kappa} < 1$. This new effect arises only because of default and discourages investment. Third, while the lack of insurance implies a precautionary motive for investment, the riskiness of human capital tends to reduce investments, since $u'(c_{1,i})$ and $w_{1,i}$ are negatively correlated.

The absence of repayment contingencies has a number of important consequences. First, default can occur in equilibrium. Second, if default happens, it is for low realizations of $w_{1,i}$ when earnings and consumption are low. Third, the option to default serves an insurance role: Given the same liabilities D, the consumption of borrowers would be even lower if they had to fully repay. As a result, eliminating default may be inefficient and could reduce investment. The policy trade-offs in this model are more interesting than in previous models.

Interest rates, implicitly given by $R(D, a, h) \equiv D/Q(D, a, h)$, contain a premium for the possibility of default. Higher $R(\cdot)$ must cover for states in which borrowers default. Ability directly impacts interest rates and credit limits, as $Q_a > 0$; for the same investments h and credit amount Q, more-able individuals are asked to repay less. This effect would lead more-able persons to invest further in human capital (especially because $Q_{ah} > 0$). Of course, higher investments in human capital would be coupled with higher liabilities, which has the potential to increase the probability of default. Lochner & Monge-Naranjo (2011a) explore the extent to which this type of model can reproduce observed default rates by ability, debt, and postschool earnings.

Ionescu (2008, 2009, 2011) analyzes models similar to this to study college enrollment, borrowing, and default decisions when credit is provided by GSL programs. Her results suggest that default rates are not higher among individuals that are most financially constrained. Most interestingly, she considers the impact of repayment flexibility (e.g., lock-in low interest rates, switching to income-contingent repayments, or alternative bankruptcy discharges) in calibrated versions of her models. Overall, she finds that the degree to which contingencies can be incorporated into repayment schemes can have significant effects on schooling. Her analysis suggests that, more than hard borrowing constraints, the lack of insurance can sometimes be the limiting factor for schooling decisions. This general conclusion is consistent with the quantitative analysis of Krebs (2003), as well as the structural estimates of Johnson (2011) and Navarro (2010).

6.2.4. Private information and limited insurance. The previous model with limited commitment and incomplete (noncontingent) debt captures empirically interesting features of default and borrowing. However, conceptually, the lack of insurance assumed above is better seen as arising from imperfect information. As such, it is natural to consider some of the lessons and modeling approaches from the vast literature on optimal contracting under private information.

First, consider ex post asymmetric information. Lenders may not be able to offer income-contingent repayments if they cannot observe the ex post circumstances of a

[42] For a saver, $D < 0$ and $Q(D, a, h) = \beta D$. Thus $Q_h = 0$ and $Q_D = \beta$.

borrower. Yet, when outcomes can be observed at a cost, the possibility of partial insurance arises. In this case, it is natural to adapt the model of costly state verification (Townsend 1979) to our human capital setting. This framework is appealing because it replicates important features both of actual bankruptcy institutions and of income-contingent student loan programs.

If a cost must be incurred for lenders to observe the postschooling earnings of a borrower, the optimal contract is remarkably simple. For high realizations of $w_{1,i}$, borrowers would simply repay a fixed amount (avoiding any verification costs), whereas an audit would take place for lower realizations. Observing the actual outcome (through verification), a risk-neutral lender would provide a constant consumption level (i.e., full insurance) to the borrower in low states of the world. Thus the worst ex post outcomes would be fully insured against (as opposed to partial insurance implicit in basic income-contingent loan programs).

Given a uniform cost of verification, the fact that higher ability implies higher earnings suggests that the probability of verification will be lower for more-able individuals, whereas their consumption is likely to be higher when verification occurs. Higher family resources would imply lower leverage and hence a lower probability of verification. These effects on the terms of insurance would tend to produce more positive ability–investment and family resources–investment relationships.

Next, consider moral hazard problems in investment. Suppose that in addition to observable investment h, young individuals must exert unobservable costly effort that affects postschooling earnings (with higher returns to effort for more-able individuals) or the probability of graduation (as in Chatterjee & Ionescu 2010). The well-known trade-off between incentives and insurance suggests that some higher-ability individuals may not obtain adequate credit because lenders foresee (correctly) the toll of debt on effort incentives.

Finally, consider postschooling moral hazard problems. Effort must be exerted to seek, keep, and improve one's job after school is over. If these efforts are costly for the borrower and unobserved by the creditor, a high debt may affect labor market outcomes, as suggested by the recent work of Braguinsky & Ohyama (2010). Foreseeing postschooling moral hazard problems, credit to human capital is likely to be reduced in the first place.

In the past two decades, an extensive literature on optimal unemployment insurance has developed (e.g., Hopenhayn & Nicolini 1997, Acemoglu & Shimer 1999, Shimer & Werning 2008). This literature generally considers the welfare of workers once human capital has been formed. Unfortunately, little is known about the joint design of optimal policies that provide both access to credit for education and insurance against postschooling labor market risks when moral hazard is a problem.

7. CONCLUSIONS

Our review of the evidence suggests that, in recent years, credit constraints have become more important for higher education decisions in the United States. The significant rise in the costs of and returns to college have increased the demand for credit well beyond the supply available from government programs. As such, the rapid expansion in private lending over the past 15 years should not come as a surprise. Providing credit for human capital, however, requires repayment enforceability and raises other incentive problems.

As in Lochner & Monge-Naranjo (2011b), we argue that explicitly incorporating these incentive problems in models of human capital formation can help explain observed cross-sectional patterns and shed new light on schooling responses to policies and economic changes.

The importance of credit constraints extends beyond their impacts on college-going. Distortions in student consumption and leisure have been documented even during periods when college outcomes were not (e.g., the early 1980s). More importantly, recent evidence highlights the adverse impacts family borrowing constraints can have on early investments in children. There are good reasons to believe that these early constraints are more pervasive and harmful than constraints at college ages. Recent work on the dynamic complementarity in investments suggests that underinvestment at early ages may explain why relaxing constraints at later ages often has little impact. Instead, government policies targeting younger ages can have much larger effects.

Credit constraints affect the degree of social mobility, the evolution of the income distribution, aggregate output, and overall welfare. Quantitative macro studies have been successful in replicating important cross-sectional and intergenerational patterns in the data. However, few fully incorporate dimensions of heterogeneity and the life cycle, as emphasized in the applied micro literature.

It is unfortunate that most of the human capital literature has ignored the vast literature on optimal contracts with incentive constraints. Above we show how standard results in this literature can be easily adapted to models of human capital formation, leading to new insights on the way abilities and family resources affect investments in human capital and a better understanding of how to best design government policies.

SUMMARY POINTS

1. Evidence suggests that borrowing constraints have become more severe for college attendance in recent years.
2. In addition to college attendance, borrowing constraints affect consumption and work/leisure while in school.
3. Evidence suggests borrowing constraints may be more salient for family investments in younger children than at college ages.
4. Early borrowing constraints and complementarity between early and late investments suggest that policies aimed at earlier ages offer more promise.
5. Credit constraints shape the degree of social mobility, income distribution, and overall development and welfare of countries.
6. Government student loan programs link borrowing to educational investments, whereas private lenders offer credit based on future earnings, which depends on ability as well as investments.
7. The link between government and private credit and schooling generates a private credit-expansion effect that strengthens educational investment responses to many education policies.
8. Lack of insurance can be a major deterrent to human capital investments. Optimal lending would provide insurance considering incentive problems arising from limited observability and limited enforceability.

FUTURE ISSUES

1. Additional work is needed to measure the extent to which early family credit constraints inhibit early childhood investments and affect later educational outcomes and earnings.
2. Future empirical studies are needed to better understand the skill production technology, especially with respect to the dynamic complementarity of investments from birth through early adulthood.
3. Given improvements in computing power, additional margins of heterogeneity and realistic life-cycle dynamics can be readily introduced in quantitative general equilibrium models of human capital.
4. To better understand cross-country differences in aggregate human capital, additional work is needed to consistently measure differences in access to and prices of credit for education.
5. Additional empirical studies are needed to better understand the extent to which different individual characteristics and choices, as well as government policies, affect repayment of government and private student loans.
6. Adapting well-known results from the optimal contracts literature to human capital accumulation problems should lead to interesting insights about the impacts of ability and family wealth on schooling, as well as the optimal design of government lending programs.
7. Little is known about the impact of student debt on postschool labor market performance. Future studies in this area can shed light on the importance of moral hazard in the design of optimal student loan contracts.
8. A promising avenue of research is integrating the optimal unemployment insurance literature with the optimal design of credit programs for human capital accumulation.

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