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by

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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, since 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.

JEL: D14, H52, I22, I23, J24.

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Contents

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. U.S.-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 last two decades have increasingly pushed more youth up against their credit limits.

Recent U.S. 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 multi-period investments in human capital. The high estimated degree of complementarity between early and late investments suggests that post-secondary 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. While 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 incorporating non-pecuniary 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 while 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 and Monge-Naranjo 2011b).

During the schooling period, individuals make human capital investments h that increase post-school labor earnings $y = w_1 a f(h)$. Each unit of h entails foregone 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]

[1] Evidence suggests that multiple skills/abilities are important in the labor market and help determine schooling decisions (see, e.g., Carneiro, Heckman and Vytlacil 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] While there is no natural metric for ability a, this is consistent with commonly used separability between

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

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

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

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

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

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:

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

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: (i) more able individuals wish to finance more investment; and (ii) 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.

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

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

where $0 \leq \bar{d} < \infty$. This *ad hoc* restriction is common in the literature on borrowing constraints and human capital. In Section 6, we discuss more realistic constraints derived

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 $\frac{\partial^2 f}{\partial a \partial h} > 0$.

explicitly from government student loan 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 ($W \geq W_{\min}(a)$). Constrained persons have high ability relative to their wealth, since $W_{\min}(a)$ is increasing in ability. Importantly, being 'unconstrained' may require much higher wealth W than is necessary to cover tuition, since 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

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

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.

Empirical Predictions. Assume constraint (6) binds when referring to $h^X(a,W)$. Then:

1. Constrained individuals under-invest in their human capital: $h^X(a,W) < h^U(a)$.

2. Unconstrained investment $h^U(a)$ is independent of wealth W, while 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, since 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 and Taber (2004) in a slightly different setting. Here, it derives from the fact that an increase in opportunity costs also raises 'full wealth' levels, while an increase in direct costs does not.[3] We discuss empirical evidence related to these results in Section 3.

Predictions about the relationship between ability and constrained human capital investment h^X are rarely discussed in the literature. Lochner and Monge-Naranjo (2011b) show that this relationship is shaped by two opposing forces: (i) More able individuals earn a higher return on human capital investment, so they would like to invest more. (ii) More able individuals have higher lifetime earnings, so they would like to consume more at all ages. This discourages investment, since 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 non-pecuniary benefits/costs of education ξ to the model above, augment utility so $U = u(c_0) + \beta u(c_1) + \xi h$. The introduction of non-pecuniary 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 $\xi > 0$, while $\frac{\partial h^U}{\partial W} < 0$ and $MR(h^U) > R$ for $\xi < 0$.[5] As such, results 2 and 3 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 non-pecuniary benefits. In contrast, result 4 is robust to the inclusion of non-pecuniary

[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, while an increase in tuition reduces resources in the schooling case when consumption is relatively low.

[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.

tastes, so tests for constraints based on the relative responsiveness of investment to direct and opportunity costs of schooling (e.g. Cameron and Taber 2004) may be more informative.

The empirical literature that incorporates unobserved heterogeneity in non-pecuniary tastes typically considers a discrete set of human capital investment choices (e.g. high school vs. college attendance).[6] Belley and 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 due to diminishing marginal utility of consumption.[8] This need not be true when borrowing constraints limit the consumption of low-wealth individuals. Constrained youth may benefit little from an increase in future labor market returns to school, since additional post-school 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

[6]Cunha, Heckman and Navarro (2005) and Navarro (2010) argue that heterogeneity in non-pecuniary 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 vs. college attendance, if net financial returns $N(a) \equiv -\tau + R^{-1}w_1af(1) - [w_0 + R^{-1}w_1af(0)] > 0$ 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 non-wage 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 non-wage benefits of college jobs became relatively more valuable for wealthier individuals.

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 re-interpret h as the quality of school conditional on school attendance.[9] 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, since they effectively invest less at lower quality schools. As noted by Carneiro and Heckman (2002), this prediction contrasts sharply with result 3 (i.e. that the marginal wage return to investment is higher for constrained youth).

3 U.S. Evidence on Borrowing Constraints and College

The rising costs of and labor market returns to college in the U.S. since the early 1980s, coupled with stable real government student loan limits, suggest that borrowing constraints may be more salient now than thirty years ago. Consistent with this view, 26% of all dependent undergraduate students at four-year public universities in the U.S. were borrowing the maximum allowable amount from the Stafford Loan Program in 1999-2000, compared to under 4% ten years earlier.[10] 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 U.S.-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.

[9]See Romano, Epple, and Sieg (2006), Avery and Turner (2010), Chade, Lewis, and Smith (2011), and Fu (2011) for explicit analyses of college quality choice.

[10]Government student loan figures are taken from Tables 2.1 and 2.7 of Titus (2002). 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 and Heckman 1998, 1999, Carneiro and Heckman 2002). Comparing education behaviors in the NLSY79 with the 1997 Cohort of the NLSY (NLSY97), Belley and Lochner (2007) find that family income has become a much more important determinant of college attendance in the early 2000s.[11] 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 and Lochner 2007).[12] 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 post-secondary 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 is due to the increased liquidity of housing wealth or to a general increase in the effect of family resources on schooling.

Belley and 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

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

[12] 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).

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. Estimated effects of family income on college entry delay are weak for both NLSY cohorts.[13]

The relationship between family income and the type of post-secondary institution individuals attend has changed since the early 1980s. While family income had little effect on the choice of two-year vs. 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 and Lochner 2007).[14] By contrast, the relationship between family income and attendance at selective high quality institutions appears to have weakened over this same period. Kinsler and Pavan (2010) estimate that (conditional on ability and family background) moving from the bottom to top income quartile increased the probability of attending a top quality college by about 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 the fact that need-based grants affect college attendance and quality decisions through price effects as well as by providing liquidity.[15] 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 and Scott-Clayton 2006, Bettinger, et al. 2009, Avery and 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

[13]Estimated effects of income on college entry delay and institution type for the NLSY79 are consistent with those of Carneiro and Heckman (2002).

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

[15]See Belley, Frenette and Lochner (2011) for a detailed accounting of net price and out-of-pocket expenditures for college by family income in the U.S. and Canada.

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) have conjectured that borrowing constraints may explain this finding, since 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, while OLS estimates more closely reflect average returns in the population. However, Carneiro and Heckman (2002) show that this is not generally the case with heterogeneous returns to schooling and self-selection.[16] 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 and Taber (2004) also examine returns to schooling, basing their analysis on results 3 and 4 in Section 2.1. 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 college quality) if borrowing constraints are important.[17] Examining men from the NLSY79, they

[16] Carneiro and 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. See Carneiro, Heckman and Vytlacil (2011) for a clear analysis of treatment effects identified from the use of different instrumental variables in the college-going context. See Heckman (2010) for a more general discussion.

[17] This argument is based on the LATE interpretation of IV estimators. Carneiro, Heckman and Vytlacil (2011) empirically show that both of these instruments identify the effects of schooling for similar subpopulations.

find no evidence in support of credit constraints.

3.3 Structural Models

A few studies estimate lifecycle 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 evaluation of a wide range of potential policies.

Cameron and Taber (2004) estimate a lifecycle 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 and 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 and Wolpin allow for unobserved heterogeneity in the ability to acquire human capital, tastes for work and school, and borrowing limits.

Estimated borrowing limits are very tight (ranging from $600 to $1000 across individuals, in 1987 dollars) — less than one-third the estimated cost of a single semester of school (about $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 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 and Wolpin conclude that nearly all of 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 government student loan 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.[18] He is able to infer 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, while Keane and 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 and Wolpin (2001): parental transfers (especially the fact that schooling-contingent transfers are greater for higher-income families) and unobserved heterogeneity are important determinants of schooling. While Johnson's estimated borrowing limits are modest relative to college costs, they are substantially greater than those of Keane and Wolpin (2001).[19] Despite greater borrowing opportunities, Johnson estimates a stronger, though 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 government student loan 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

[18]Like Keane and Wolpin (2001), he also uses data on schooling, work, assets, and wages. Since 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.

[19]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 for some types.

studies for very different reasons. As discussed above, estimates from Keane and 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 post-school unemployment), prevents individuals from taking on much debt. His estimates suggest that very few would choose to borrow more than $6,000.[20]

Navarro (2010) also explores the importance of heterogeneity, uncertainty, and borrowing constraints as determinants of college attendance in a lifecycle framework. At each age, borrowing constraints are given by the lowest possible discounted future income (i.e. the 'natural' limit of Aiyagari (1994)).[21] 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 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 lifecycle schooling models with uncertainty. The demand for credit

[20]While 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.

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

may be much higher with explicit insurance mechanisms or implicit ones such as bankruptcy, default, or other options (e.g. deferment and forgiveness in government student loans). 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 is needed as we discuss in Section 6.

The results of Keane and 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: (i) All parents have similar tastes for schooling, but poor parents may be constrained in what they can afford to pass on to their children. (ii) All parents have similar tastes for schooling, but wealthier parents prefer to buy more of it like they do other normal goods. (iii) 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.

While the results of Keane and 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 and Wolpin (2001) and Johnson (2011). This is also true in studies explicitly analyzing education gaps by family income (e.g. Cameron and Heckman 1998, Carneiro and Heckman 2002, Belley and 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, Lochner and Taber (1998) and Gallipoli, Meghir and Violante (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 and 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 U.S. as a whole. While Stinebrickner and Stinebrickner (2008) find that many Berea students live on a very 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 drop out rates (by the beginning of year two) are about 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 about 11 percentage points.

Brown, Scholz and Seshadri (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; although, 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 under-invest. 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 post-school parental transfers. Brown, Scholz and Seshadri show that in their framework, total human capital investment should be more sensitive to a tuition subsidy among constrained youth than among unconstrained youth.[22]

Based on these insights, Brown, Scholz and Seshadri 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 U.S. during the 1970s, 1980s, and 1990s. They identify 'constrained' youth as those receiving no post-school family transfers.[23] Because the HRS do 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. 4 vs. 0 years of sibling overlap in college) increases average schooling by 0.2 years. 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 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, while it has become less important for attendance at very selective institutions. Borrowing constraints could also delay college attendance, but the evidence reveals little

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

[23] 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.

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 and Heckman 1998, Keane and Wolpin 1997, 2001, and Carneiro and Heckman 2002). Moreover, evidence from consumption allocations suggests that liquidity constraints are most salient for younger households (e.g. Meghir and Weber 1996, Alessie, Devereux, and Weber 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 and Currie 2006, or Cunha, et al. 2006, Heckman, et al. 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 and Brooks-Gunn 1997, Duncan, et al. 1998, Levy and Duncan 1999, Caucutt and Lochner 2006, 2011).[24] More generally, recent studies show that exogenous increases in family income lead to improvements in early child development.[25]

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, while high quality private schools and

[24]Carneiro and Heckman (2002) argue that early income should have a larger effect than later income due 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 enrolment 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 and 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.

[25]See, e.g., Akee, et al. (2010), Løken (2010), Løken, Mogstad and Wiswall (2010), Duncan, Morris and Rodrigues (2011), Milligan and Stabile (2011), and Dahl and Lochner (forthcoming).

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 periods (e.g. parental time vs. schools vs. family goods inputs).[26] 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 and 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 lifecycle. 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 and Wolpin (2001) and Cameron and Heckman (1998).

The estimates of Cunha, Heckman, and Schennach (2010) suggest that investments are quite complementary over time, with the degree of dynamic complementarity growing with age for cognitive skills.[27] 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 lifecycle. 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

[26]See, Del Boca, Flinn, and Wiswall (2010), Todd and Wolpin (2003, 2007), and Cunha, Heckman and Schennach (2010) for analyses that consider multiple inputs each period.

[27]Cunha, Heckman, and Schennach (2010) estimate elasticities of substitution ranging from 0.4 to 1.5. They use data from the Children of the NLSY and exploit a dynamic non-linear factor structure and multiple measurements for cognitive and non-cognitive skills and family investments.

over the lifecycle when financial markets are imperfect.[28] Cunha (2007) estimates a similar lifecycle human capital production technology to that of Cunha, Heckman and Schennach 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 lifecycle borrowing. Parents cannot leave negative transfers to their children; however. Caucutt and Lochner (2011) develop and calibrate a similar dynastic overlapping-generations model; however, they incorporate age-specific borrowing constraints. Focusing on 'early' vs. 'late' investments, they consider a six-period model of the lifecycle, with 'late' investments corresponding to different levels of educational attainment.[29]

Caucutt and Lochner find that many young and middle-age parents are borrowing constrained, including some with higher education. However, like Keane and 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 (e.g. high school completion and college). Long-run effects of such a policy are quite different. Since 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 and 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 in-

[28] Del Boca, Flinn and Wiswall (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 and 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 and Urrutia in Section 5.

[29] Both Cunha (2007) and Caucutt and Lochner (2011) identify a similar degree of complementarity between early and late human capital investment to that estimated by Cunha, Heckman and Schennach (2010).

vestments 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 and Lochner (2011) show that ignoring early investment responses would cause researchers to significantly under-estimate 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.[30] Yet, less attention has been given to the role of the different factors, including credit constraints, that explain cross-country human capital differences.[31] 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 and Ripoll (2011) shows that introducing credit constraints significantly improves the ability of a Ben-Porath (1967) 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. In a frictionless model, aggregate human capital investments are entirely determined by the life-span of individuals in a country, its total factor productivity (TFP) and tax policies. Cordoba and Ripoll show that credit constraints can also add parental lifetime income, family size, and the supply of public education as determinants of education

[30] See, e.g., Hall and Jones (1999), Mankiw, Romer and Weil (1992), and Klenow and Rodriguez (1997).

[31] However, see Bils and Klenow (2000), Kaboski (2007), Manuelli and Seshadri (2010).

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 towards less able youth from wealthier families. Empirically, this distortion could show up in a country's schooling sector TFP (as in Caucutt and Kumar 2003) or in its TFP for consumption goods (as in Benabou 2002). 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 and Tomes (1979, 1986) and Loury (1981) pioneered the development of fully consistent economic models of the 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.[32] Other, simpler forms of preferences are also sometimes used. 'Paternalistic' preferences assume that parents directly value human capital investments or outcomes, or even earnings.[33] Finally, 'warm-glow' preferences assume that parents directly value transfers/bequests to their children, not caring what children do with the money.[34] The form of intergenerational preferences can have important consequences.

The pioneering work by Becker and Tomes (1979) and Loury (1981) assumes all human capital is in the form of parental investments in their children. Both analyses rule out finan-

[32]See, e.g., Becker and Tomes (1986), Loury (1981), and Benabou (2002).
[33]Glomm and Ravikumar (1992) and Fernandez and Rogerson (1998) use variations of these preferences.
[34]See, e.g., Galor and Zeira (1993) and De Nardi (2004).

cial 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 since 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. On the other hand, with paternalistic preferences, Becker and 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 and Tomes (1986) extend their earlier analysis, incorporating ability-investment complementarity, non-negative 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 and Zeira (1993) introduce *indivisibilities* in human capital investment: individuals either attend or do not attend college. In the presence of credit market imperfections (modelled as a positive gap between borrowing and lending interest rates), Galor and Zeira show that non-convexities in investment can lead to multiple steady states and, hence, can explain persistent differences in per capita output across countries. The steady states in Galor and Zeira fall into three categories: (i) global poverty traps (the entire population is unschooled), (ii) a perfect caste system with "individual poverty trap" where some dynasties are forever unschooled while the others are forever schooled;

or (iii) 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 and Tomes (1979).[35] The key for these differences in aggregate investments and social mobility is non-convexity in schooling choices, not the form of preferences. Indeed, Caucutt and Kumar (2003) find similar results with altruistic preferences.

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

Caucutt and 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 and 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 U.S.

Restuccia and Urrutia (2004) extend the dynastic framework of Caucutt and Kumar (2003) to include a period of early investment in children along with a college attendance de-

[35] 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) post-investment 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.

cision 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 U.S. data, they argue that differences in early investments by parental income are largely responsible for observed levels of intergenerational persistence, since the lack of credit availability is particularly problematic for poor young parents (for reasons discussed previously in Section 4).

Gallipoli, Meghir and Violante (2011) incorporate schooling in a lifecycle 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 lifecycle earnings, consumption and labor supply behavior in the U.S.

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.[36] However, as argued by Boldrin and Montes (2004), intergenerational conflict can be averted – and efficiency restored – if public schooling policies are tied to other government transfers. While they consider a very 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: (i) heterogeneity; (ii) endogeneity of private credit constraints; and (iii) risks and incentive problems.

Heterogeneity in abilities and family resources can be a major limitation for the efficacy of

[36]This presumes 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 and Montes (2004).

government programs. Benabou (2002) considers progressive income taxation and education subsidies in economies with heterogeneous agents and characterizes the trade-offs between efficiency (and growth) with 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 over-investment by lower ability individuals.[37]

Caucutt and Kumar (2003) and Gallipoli, Violante and Meghir (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 over-invest. 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 and Kumar (2003) further find that a combined need- and merit-based subsidy does no better in terms of welfare than a simple need-based subsidy. Gallipoli, Violante and Meghir (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 and 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. While this policy increases college enrollment rates, it also increases college failure rates, reducing the efficiency of the college sector.

Incorporating early investment endogeneizes the formation of — and heterogeneity in —

[37]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 and Ravikumar (1992) and Fernandez and Rogerson (1998).

ability, effectively moving the model closer to one with homogeneous agents as in Boldrin and Montes (2004). Indeed, Restuccia and 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 for the analysis of government policies that is typically neglected 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 and Gervais (2006) show that when credit constraints are endogenously driven by limited commitment, transfers to young and old (from middle-age workers) could *reduce* the supply of resources for youth to invest in human capital, since default incentives induce private lenders to reduce student credit by more than the youth transfer amount.[38]

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 and 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 Buera, Kaboski and Shin (2011) do 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.

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

6 The Nature of Borrowing Constraints for Education

Despite extensive interest on the impact of credit constraints on the market for human capital, little attention has been paid to the underlying institutions and incentive problems 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, then introduce uncertainty about returns to human capital.

6.1 Government Student Loans and Limited Commitment

Many students turn to government student loan (GSL) programs and private lenders to help finance tuition and living costs while enrolled in college.[39] GSL programs explicitly link credit to educational expenditures, while 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.

GSL programs. Lending programs supported by the federal U.S. 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 non-schooling 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

[39]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, Frenette and Lochner (2011) for a detailed description of need-based aid.

and lifetime limits.[40] Third, GSL programs typically have extended mechanisms to enforce repayment as compared to unsecured private loans. For example, student loans cannot be expunged through bankruptcy; tax offsets and wage garnishments can be used to collect amounts owed.[41]

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 Subsection 6.2, we consider more general models with default.[42]

Private Lending. The importance of private lending markets for schooling has skyrocketed from virtually zero in the early 1990s to over $15 billion in 2005-06, 20% of all student loan dollars distributed (College Board 2006). Credit cards have also become an important source of funds for students (Nellie Mae 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. Andalfatto and Gervais 2006, Lochner and Monge-Naranjo 2011b).[43] 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.[44] Since 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 co-determined in equilibrium.

Assume that the cost of default on private loans is equal to a fraction $0 < \tilde{\kappa} < 1$ of

[40] From 1993-2007, undergraduate annual Stafford Loan limits for dependent students ranged from $2,625 (first year) to $4,000 (years 3-5) with a cumulative total of $23,000. Graduate students could borrow $18,500 per year, accumulating up to $138,500 in Stafford Loan debt.

[41] See Ionescu (2008, 2009, 2011) and Lochner and Monge-Naranjo (2011b) for a more detailed description of GSL programs.

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

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

[44] Gropp, Scholz, and White (1997) empirically support this form of response by private lenders.

labor earnings.[45] Then, borrowers repay if and only if the payment Rd_p is less than the punishment cost $\tilde{\kappa} a f(h)$. As a result, credit from private lenders is limited to a fraction of post-school earnings

$$d_p \leq \tilde{\kappa} R^{-1} a f\left(h\right), \tag{10}$$

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 (9), and d_p from private lenders, subject to (10), is constrained by

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

Assuming GSL repayments are fully enforced, government credit does not crowd out private credit. Lochner and Monge-Naranjo (2011b) show that a similar constraint holds in a lifecycle 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.

Empirical Implications. Lochner and 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, the GSL 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, those exhausting GSL credit choosing to borrow from private lenders. Private lenders have responded by endogenously raising their credit limits, though 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

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

private credit to investment and is consistent with the findings of Keane and Wolpin (2001), Stinebrickner and Stinebrickner (2008), and Johnson (2011). Indeed, Lochner and Monge-Naranjo show that constrained individuals may not under-invest at all, since 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, since 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 and 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 and 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, while 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 with fixed constraints, 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. Incorporating 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 one (i.e. $w_0 = 0$ and $\tau = 1$). Assume now that the second period price of human capital is stochastic and can take on $i = 1, ..., N$ possible realizations. Let $p_i > 0$ denote the probability of realization $w_{1,i}$ which we order so that $w_{1,1} < w_{1,2} < ... < w_{1,N}$. Assume that the individual and potential lenders observe the true probabilities as well as individual ability a and initial assets W.[46] 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.

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

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

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. $q_i = \beta p_i$.

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:

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

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 have 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 $i = 1, ..., N$.

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 raise to the

[46]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 and Stinebrickner (forthcoming).

'participation constraint' $u\left[w_{1,i}af\left(h\right)-D_i\right] \geq V^D\left(w_{1i},a,h\right)$, which limits the credit and insurance of borrowers.

Letting $\lambda_i \geq 0$ denote the (discounted) multiplier on participation constraint $i=1,...,N$, optimal debt holdings satisfy $u'\left(c_0\right)=\left(1+\lambda_i\right)u'\left(c_{1,i}\right)$. 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 and/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 his earnings. This implies $V^D\left(w_{1i},a,h\right)=u\left[\left(1-\tilde{\kappa}\right)w_{1i}af\left(h\right)\right]$, so participation constraints reduce to simple 'solvency' constraints of the form $D_i \leq \tilde{\kappa}w_{1,i}af\left(h\right)$ for all $i=1,...,N$. 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 $D_i=\tilde{\kappa}w_{1i}af'\left(h\right)$. There is perfect smoothing across low earnings states but only limited insurance in high earnings states.[47] Optimal human capital investment $h^{LC}\left(a,W\right)$ satisfies

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

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 earlier 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 earlier. Furthermore, default does not occur in equilibrium, since 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.

[47] 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.

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, $w_{1,i}$. Due 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, $\Pr[w_{1,i} < \tilde{w}_1(D, a, h)]$, is weakly increasing in the level of debt D and decreasing in ability a and human capital h. In exchange for a promise to pay $D > 0$, 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, since increasing debt can more than proportionally reduce the probability of repayment.[48] 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.[49] 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

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

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

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

[49] See Lochner and Monge-Naranjo (2011a) for a complete analysis of the general case.

condition for optimal h is

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

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.[50] 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 since $0 < \tilde{\kappa} < 1$. This new effect arises only because of default and discourages investment. Third, the lack of insurance implies a precautionary motive for investment; however, the riskiness of human capital can also reduce investments as discussed in Krebs (2003).

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, since $Q_a > 0$; 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 since $Q_{ah} > 0$). Of course, higher investments in human capital would be coupled with higher liabilities, which has the potential to increase the probability of default. Lochner and Monge-Naranjo (2011a) explore the extent to which this type of model can reproduce observed default rates by ability, debt, and post-school earnings.

Ionescu (2008, 2009, 2011) analyzes models similar to this in order to study college enrollment, borrowing, and default decisions when credit is provided by GSL programs. Her

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

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).

Private Information and Limited Insurance. The previous model with limited commitment with incomplete (non-contingent) 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 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 both replicates important features of actual bankruptcy institutions and of income contingent student loan programs.

If a cost must be incurred for lenders to observe the post-schooling 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), while 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, while 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 post-schooling earnings (with higher returns to effort for more able individuals) or the probability of graduation (as in Chatterjee and 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 *post-schooling 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 and Ohyama (2010). Foreseeing post-schooling moral hazard problems, credit to human capital is likely to be reduced in the first place.

In the last two decades, an extensive literature on optimal unemployment insurance has developed.[51] 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 post-schooling 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 U.S. 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 fifteen years should not come as a surprise. Providing credit for human capital, however, requires repayment enforceability and raises other incentive problems. As in Lochner and Monge-

[51] For instance, Hopenhayn and Nicolini (1997) Acemoglu and Shimer (1999) and Shimer and Werning (2008), among many others.

Naranjo (2011b), we have argued 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 under-investment 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 lifecycle, 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. We have shown 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.

8 Summary Points

- Evidence suggests that borrowing constraints have become more severe for college attendance in recent years.
- In addition to college attendance, borrowing constraints affect consumption and work/leisure while in school.
- Evidence suggests borrowing constraints may be more salient for family investments in younger children than at college ages.
- Early borrowing constraints and complementarity between early and late investments suggest that policies aimed at earlier ages offer more promise.
- Credit constraints shape the degree of social mobility, income distribution and overall development and welfare of countries.
- Government student loan programs link borrowing to educational investments, while private lenders offer credit based on future earnings, which depends on ability as well as investments.
- The link between government and private credit and schooling generates a private 'credit expansion effect' which strengthens educational investment responses to many education policies.
- 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.

9 Future Issues

- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- Little is known about the impact of student debt on post-school labor market performance. Future studies in this are can shed light on the importance of moral hazard in the design of optimal student loan contracts.
- 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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