A New Test of Borrowing Constraints for Education

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Abstract

We discuss a simple model in which parents and children make investments in the children's education, investments for other purposes, and parents can transfer cash to their children. We show that for an identifiable set of parent-child pairs, parents will *rationally* under-invest in their child's education. For these parent-child pairs, additional financial aid will increase educational attainment. The model highlights an important feature of higher education finance, the "expected family contribution" (EFC) that is based on income, assets, and other factors. The EFC is neither legally guaranteed nor universally offered: Our model identifies the set of families that are disproportionately likely to not provide their full EFC. Using a common proxy for financial aid, we show, in data from the Health and Retirement Study, that financial aid increases the educational attainment of children whose families are disproportionately likely to under-invest in education. Financial aid has no effect on the educational attainment of children in other families. The theory and empirical evidence identifies a set of children who face quantitatively important borrowing constraints for higher education.

There has been long-standing interest in whether U.S. students have access to sufficient resources to support efficient human capital investment (see, for example, Becker, 1967). But despite a large literature, no paper on borrowing constraints for higher education focuses on the family's role in financing college, particularly through their expected family contribution (EFC). The EFC is the difference between a child's cost of attending college and what the federal financial aid formulas determine is the family's "adjusted available income" for college. The EFC, however, is neither legally guaranteed nor universally offered. Children whose parents for one reason or another refuse or are unable to make their EFC may face financial constraints in attending college.[1]

The detailed data that are needed to examine the family's role in financing college, namely on parental income, assets, demographic factors, and the contributions parents actually make for college, are scarce. Moreover, the EFC is determined, in part, by the college that children attend. Consequently, the EFC is endogenous to the outcomes, namely college entry or years of completed education, that are of typical interest to researchers. Even if an arguably exogenous EFC measure could be computed, borrowing constraints may have their most important effects on the decision of whether or not a child goes to college. For a child who ends up not going to college, the parent will clearly not provide college expenses. So the counterfactual – what the parent would have contributed had the child gone to college – is unobserved. This unobserved counterfactual makes it difficult to examine directly the effect of parents' education transfers on educational attainment.

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[1] Diana, posting on 1/11/2005 to the Becker-Posner Blog, writes, "…Currently if you are under 25 and not in graduate school you are considered dependent on your parents' income and have to include their income on you FAFSA which will count against you when figuring your expected family contribution. For those of us who did not receive any financial support from parents other than cosigning loans this is a real kick in the ass. Not only is my family lower middle class and unable to contribute to my education, but the government will tell me that they expected them to contribute and will punish me by lowering my available loan total" (http://www.becker-posner-blog.com/2005/01/governments-role-in-student-loans-becker.html#comments).

In this paper we introduce a new approach to studying borrowing constraints and higher education. Our starting point is the observation that parents and children are distinct decision-makers. Specifically, in our model we assume parents face complete credit markets and they care about their own consumption and about the well-being of their adult child. We assume a child cannot borrow against future earnings and they care only about their own consumption (and not their parent's). We show the child's education may be suboptimal due to borrowing constraints. The parent may be poor relative to the child or care too little about the utility of their child to provide financial help for college, since parents cannot access the returns to their child's education. Alternatively parents and children may disagree about the optimal investment in education because of the possibility that the child will end up relying too heavily on the parent.

There are two regions in the equilibrium of our model. One region is distinguished by the presence of post-schooling cash transfers (and parents are relatively wealthy, or altruistic, or the child's ability is relatively modest). In this portion of the equilibrium, children achieve the efficient level of investment in education, so the return to education equals the financial market rate of return. There are strategic concerns, however, so the parent "ties" a portion of their intergenerational transfers by making it education-specific. The other region is distinguished by no post-schooling cash transfers (and parents are relatively poor, or egoistic, or the child is relatively able). In this portion of the equilibrium, there will be underinvestment in the child's education, so the return to additional human capital investment will exceed the financial market rate of return. It is precisely this group of parents that will *rationally* not meet their EFC. Parents will tolerate this inefficiency because they have no way to write a binding contract to ensure that some portion of the child's future earnings will be repaid in return for supporting their child's education.

Financial aid will have sharply different effects on parent-child pairs in the two regions of the model's equilibrium. For parents who make post-college transfers, additional financial aid should have no effect on educational attainment, because parents will already make the efficient level of investment in their child's education. But children of parents who do not make post-college transfers under-invest in education, due in part to their inability to borrow against future earnings. For these children, increases in financial aid will increase educational attainment.

For expositional clarity, our model abstracts away from important considerations both in parent-child relations and in higher education finance. Among the most important is the fact that a child's post-college earnings are uncertain, which may affect post-college transfers, and the fact that some children finance college by working while in school or by extending the amount of time they attend college. We extend the model to address these concerns in an appendix and show that the central intuition still holds: financial aid should be more likely to affect the educational attainment of children whose parents do not make post-college transfers than children whose parents do make post-college transfers.

Examining the empirical implications of the model requires data on three things: parent-child pairs, financial aid, and intergenerational transfers, ideally for a substantial period following college so we can separate parent-child pairs into those parents who do and those who do not make post-college transfers. No dataset has all three features. The Health and Retirement Study (HRS) comes close, with good data on parent-child pairs and intergenerational transfers over a long period. The HRS also offers a good proxy for financial aid. The dollar amount of financial aid will depend on the overlap of a child's college years with those of his or her siblings. As a result, we rely on the birth spacing of siblings as a proxy for variation in students' federal aid.

As implied by our analytic model, we find a positive and statistically significant relationship between educational attainment and sibling overlap when no post-schooling cash transfers are reported, and no significant relationship when positive transfers are reported. Our primary empirical model is based on variation in birth spacing among children within the same family and our results are consistent across many alternative specifications. The magnitude of the association implies a difference in educational attainment of 0.4 years of schooling between a constrained child with four years of sibling overlap relative to a child with no sibling overlap while in college. A child with 4 years of sibling overlap while in college would receive, on average, about $3,600 more in financial aid (in 2009 dollars) over 4 years than an otherwise equivalent children with no years of sibling overlap. About half of the children in the sample are potentially constrained. This implies that $3,600 in additional financial aid would result in 0.2 additional years of schooling for the sample, on average. Borrowing constraints for higher education appear to be important for children in families where parents are unwilling or are unable to meet their expected family contribution.

I. A model of intergenerational transfers

The starting point for our model is the small theoretical literature on collective family schooling decisions.[2] To generate an equilibrium that distinguishes between education and cash transfers and the timing of these, there must be scope for disagreement between parents and children over children's investments. Repeated transfer opportunities can generate a threat of strategic over-reliance of a child on an altruistic parent. The possibility of strategic behavior by

[2] When studies of borrowing constraints for education include analytic models, they invariably assume that families make unitary college decisions based on parents' resources and children's ability. Two interesting papers that do not examine borrowing constraints but do investigate behavioral consequences of parental transfers to school-age children are Sauer (2003) and Perozek (2005). Sauer examines the effects of parental transfers during law school on borrowing, work while in school, and post-school earnings for a sample of University of Michigan law school graduates. Perozek characterizes altruistic transfer rules in a dynamic setting and empirically explores the education investments of a parent and multiple children using the HRS.

children may lead parents to tie transfers in the form of education or, as we discuss in our model, to under-invest in education, given that the parent cannot access the returns from the child's education.[3]

a. The Economic Environment

Consider a two-period model where parents care about their children's utility. We assume that parents and children make independent, non-cooperative decisions.[4] In particular, the parent moves first, choosing her consumption and physical capital investment, along with the dollar amounts of a cash transfer to the child and a tied transfer for college education. The child sees these choices and then decides how much to consume, invest in schooling, and save. In the second period, the parent again consumes and chooses a cash gift to the child; the child's only action is to consume the gift and the returns to his various investments. While the parent has full

[3] The Samaritan's Dilemma, evident here in the possibility of the child's over-reliance on the parent, was first described by Buchanan (1975), and results on the Samaritan's Dilemma in Lindbeck and Weibull (1988), Bergstrom (1989), and Bruce and Waldman (1990) have also shaped our approach. Bruce and Waldman (1991) are the first to connect the Samaritan's Dilemma to the motive for tied transfers. Pollak (1988) uses preferences for education to motivate parents' investments, and observes that distinctions among transfer forms must rely on a disagreement between parents and children and that effective tied transfers cannot function as collateral or be resold.

[4] Noncooperation is a critical assumption of our work. Altonji, Hayashi and Kotlikoff (1992) reject income pooling, an implication of both the unitary model and the non-cooperative model with active financial linkages, for extended families. In Brown, Mazzocco, Scholz and Seshadri (2006), we argue that the Altonji, Hayashi and Kotlikoff income pooling result allows one to reject not only non-cooperative behavior with active financial linkages, but also the standard cooperative model under income-independent Pareto weights. In our 2006 paper, we repeat their test using data on independent parent and child households only, and like the earlier work, we also reject income pooling. The rejection of income pooling is consistent with non-cooperative interactions and inactive financial linkages that characterize our modeling approach.

An implication of our model of one-sided altruism is that there will be no child-to-parent transfers. The empirical literature suggests that child-to-parent transfers are uncommon and small relative to either parent-to-child transfers or transfer support for college education. Gale and Scholz (1994), for example, look at transfer patterns in the 1986 Survey of Consumer Finances. They find that 83.6 percent of total recipient-reported transfers are from parents, while only 3.1 percent of total recipient-reported transfers are from children. Further, the annual flow of transfer support to parents that they infer from the data is roughly a tenth of the annual flow of support to children or the annual flow of transfers for college education. When transfers are given from younger to older generations, it is typically done when parents are elderly, but even then it is fairly uncommon. McGarry and Schoeni (1995), for example, find that 6.7 percent of 51-61 year old HRS respondents in 1992 report gifts to parents, while 29 percent report gifts to non-coresident children.

access to credit, we assume that the child cannot borrow against his future income.[5]

Define *a* as the total parent and child investment in physical capital, and define *e* as their total investment in the child's postsecondary education. Assume that the rate of return on physical capital is constant at *R* and the return to total human capital investment *e* is *h(e)* such that $h'(\cdot) > 0,\ h''(\cdot) < 0$ and $h'(0) > R.$ A child can receive financial aid τ, which augments family human capital investments. Total human capital investment $e = e(e^p + e^k, \tau)$, with $\frac{\partial^2 e}{\partial(e^p + e^k)\partial\tau} > 0$, where superscript *p* identifies parents and superscript k identifies children. We also assume that $h'(e(0,\tau)) \geq R$. In the course of our analysis we consider two particular descriptions of financial aid. In the first, aid functions as a price subsidy, so that $e = (1+\tau)(e^p + e^k)$: the marginal dollar invested in education has a return of $(1+\tau)$. The analogy we have in mind is to the practical case where the marginal dollar a family invests is leveraged though federal subsidized loan programs, such as guaranteed student loans. In the second, aid is given as a lump sum transfer, so that $e = e^p + e^k + \tau$. The analogy we have in mind is to all cases in which aid is inframarginal. This occurs, for example, when a family receives a Pell grant or subsidized loan, but the grant or loan is less than total $e,$ so the last dollar spent on education is wholly out-of-pocket.

The child and parent utilities are given by

$$U^k(c_1^k, c_2^k) = u(c_1^k) + \beta u(c_2^k) \text{ and}$$
$$U^p(c_1^p, c_2^p, c_1^k, c_2^k) = u(c_1^p) + \beta u(c_2^p) + \alpha\left(u(c_1^k) + \beta u(c_2^k)\right),$$

[5] As discussed in Brown *et al.* (2006), both assumptions that we make – non-cooperative behavior and children have more limited ability to borrow than parents – are necessary to obtain empirical predictions on the timing and magnitude of transfers.

where c_t^j represents the period t consumption of agent j, α expresses the parent's degree of purely altruistic concern for the child's welfare, and β is the rate at which each agent discounts future utility. Single period utility of consumption for each agent, $u(\cdot)$, is such that $u'(\cdot) > 0,\ u''(\cdot) < 0$ and $u'(0) = +\infty$.

The parent acts as a Stackleberg leader, moving first in period 1, choosing c_1^p, a^p (assets), e^p and first period transfer to the child, g_1, subject to constraints $c_1^p + a^p + e^p + g_1 \le x^p$, $g_1 \ge 0$ and $e^p \ge 0$.[6] As a result of the one-sided altruism and non-cooperative interaction between the parent and child, the parent is unable to draw resources from the child through a negative transfer or through negative investment in the child's education. The non-negativity of parental cash transfers in the second period will play a crucial role in determining equilibrium investments.

The child takes the parent's choices of c_1^p, a^p and e^p as given, choosing c_1^k, a^k and e^k subject to constraints $c_1^k + a^k + e^k \le g_1$, $e^k \ge 0$ and $a^k \ge 0$. In the second period, the parent determines consumption c_2^p and the amount of the second period cash transfer to the child, g_2, subject to constraints $c_2^p + g_2 \le Ra^p$ and $g_2 \ge 0$. The child consumes his total resources, so that $c_2^k = Ra^k + h(e) + g_2$.

b. Period 2

The parent's problem in the second period is

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[6] The assumption that $u'(0) = +\infty$, combined with the child's zero endowment, implies that $g_1 \ge 0$ does not bind at the parent's optimum; $e^p \ge 0$, however, may bind. Key results in this paper hold even when the child has an endowment that can support first period consumption (Brown *et al*., 2006).

e^p is the parent's optimal expenditure on education, which will depend on income, altruism, and the shape of the child's human capital production function, among other factors. The EFC, in contrast, is an important determinant of the aid that a child will receive but it is not the optimal family educational expenditure.

$$\max_{g_2 \geq 0} \left\{ u(Ra^p - g_2) + \alpha u(Ra^k + h(e) + g_2) \right\},$$

and the optimal transfer, given the second period resources of the parent and child, is

$$g_2(Ra^p, Ra^k + h(e)) = \begin{cases} g_2 \text{ such that } u'(Ra^p - g_2) = \alpha u'(Ra^k + h(e) + g_2) \\ \qquad \text{where } u'(Ra^p) < \alpha u'(Ra^k + h(e)), \\ 0 \quad \text{otherwise.} \end{cases} \tag{1}$$

When the transfer that equates second period marginal utilities across generations is positive, the parent achieves his/her preferred allocation of the family's total final-stage resources.[7] The parent's altruism toward the child implies that the final transfer decreases with the child's assets and earnings, no matter what choices preceded them, so second period transfers, when made, are compensatory. The key point of equation (1) for our purposes, however, is that when the parent's marginal utility from consuming everything in period 2 exceeds the marginal utility they would get from the first dollar of cash transfers, the parent will not make second period transfers. Whether or not second period cash transfers are made distinguishes the two segments of the equilibrium.

c. Period 1: Child

In the first period, the child determines his or her own consumption, saving, and educational investment given the $(g_1,\ a^p,\ e^p)$ chosen by the parent. The child's problem is

$$\max_{c_1^k, c_2^k, e^k \geq 0, a^k \geq 0} \left\{ u(c_1^k) + \beta u(c_2^k) \right\}$$
$$s.t.\ \ c_1^k + e^k + a^k \leq g_1,$$
$$c_2^k = Ra^k + h(e) + g_2(Ra^p, Ra^k + h(e)),$$
$$g_2(Ra^p, Ra^k + h(e)) \text{ as in (1) and } e = e(e^p + e^k, \tau).$$

[7] This surprisingly robust prediction is the focus of the theory and empirical analysis in Altonji, Hayashi and Kotlikoff (1997).

The function $g_2(Ra^p,\ Ra^k + h(e))$ is continuous but non-differentiable where $\alpha u'(Ra^k + h(e)) = u'(Ra^p)$.

The first order conditions for the child's problem make it clear that whenever $g_2 > 0$, the child would like to over-consume in the first period in order to achieve consumption path $\{c_1^k, c_2^k\}$ such that

$$u'(c_1^k) = \beta \max\left\{R, h'(e)\frac{\partial e}{\partial(e^p + e^k)}\right\}\left(1 + \frac{\partial g_2}{\partial(Ra^k + h(e))}\right)u'(c_2^k)\,. \qquad (2)$$

Since the second period gift described by (1) compensates the child for low post-schooling consumption, partial derivative $\frac{\partial g_2}{\partial(Ra^p + h(e))}$ is negative. Hence equation (2) indicates that the child would like to exploit their parent's altruism by consuming more in the first period and less in the second relative to the standard intertemporal consumption smoothing condition $u'(c_1^k) = \beta \max\left\{R, h'(e)\frac{\partial e}{\partial(e^p + e^k)}\right\}u'(c_2^k)$. The consumption profile satisfying equation (2) extracts a greater post-schooling gift from the parent in the event that $g_2 > 0$. The child's preferred consumption profile will be possible only if there exists an $e^k \geq 0$ and $a^k \geq 0$ satisfying (2), given the parent's choices. We show in Appendix A, the parent will choose g_1, e^p and a^p such that $e^k \geq 0$ and $a^k \geq 0$ bind, thus eliminating the strategic concern (and equation (2) ends up not holding in the $g_2 > 0$ case).

d. Period 1: Parent

In period 1, the parent chooses c_1^p, g_1, e^p and a^p to maximize his or her utility, subject to $c_1^p + a^p + e^p + g_1 \leq x^p$, $g_1 \geq 0$ and $e^p \geq 0$. We note three features of the model in proposition 1.[8]

[8] Proofs of both propositions are given in Appendix A.

Proposition 1*: (i)* Equilibrium consumption levels $\{c_1^p, c_2^p, c_1^k, c_2^k\}$ are unique. *(ii)* If $g_2 > 0$ in any equilibrium, then $h'(e)\frac{\partial e}{\partial(e^p+e^k)} = R$ and the equilibrium transfers (e^p, g_1, g_2) are unique. *(iii)* If $g_2 \geq 0$ binds in any equilibrium, then $h'(e)\frac{\partial e}{\partial(e^p+e^k)} > R$ – there is inefficient investment in education from the family's point of view – and the equilibrium transfers need not be unique, since only the sum, $g_1 + e^p$, is determined.

The solution partitions the parameter space into two regions. In one region $g_2 > 0$ and $h'(e)\frac{\partial e}{\partial(e^p+e^k)} = R$. The parent's c_1^p, g_1, e^p and a^p meet conditions

$$\begin{aligned} &u'(c_1^p) = \alpha u'(c_1^k),\ u'(c_1^p) = \beta R u'(c_2^p),\ h'(e)\frac{\partial e}{\partial(e^p+e^k)} = R,\ \text{and } u'(c_2^p) = \alpha u'(c_2^k), \\ &\text{where } c_1^p = x^p - g_1 - e^p - a^p,\ c_1^k = g_1,\ c_2^p = Ra^p - g_2,\ e^k = 0 \text{ and } c_2^k = h(e(e^p,\tau)) + g_2. \end{aligned} \qquad (3)^9$$

The solution will be in this region when parents are relatively wealthy, or altruistic, or the child's return to human capital investment falls relatively quickly to the real interest rate.

In the $g_2 > 0$ equilibrium strategic concerns arise so the parent bears all responsibility for the investment in the child's education. The child realizes that the parent will be in the interior of the transfer region in the second period. Hence, given the opportunity, the child would over-consume in the first period, as shown in equation (2). The parent takes this into account and makes a cash gift of only what she prefers for the child to consume in the first period. The parent ties all additional first period transfers to education, exhausting the region of educational investment that yields a return at or above the real interest rate. Should the parent prefer to claim some part of the return to education for herself, she can easily accomplish this by withholding a portion of intended post-schooling transfers. To summarize, we find that families in the $g_2 > 0$

[9] Note that the fact that $e^k = 0$ in the $g_2 > 0$ case arises as a product of the equilibrium. The parent's first period choices in the $g_2 > 0$ case cause the $e^k \geq 0$ constraint to bind, avoiding the strategic over-consumption by the child reflected in equation (2).

equilibrium face strategic concerns, yet they make efficient educational investments and hence they relieve the child's educational borrowing constraint.

The other region of the parameter space occurs where conditions (3) can be met only with $g_2 < 0$. In this case, $g_2 = 0$ and $h'(e)\frac{\partial e}{\partial(e^p+e^k)} > R$.[10] The equilibrium is described by

$$
\begin{aligned}
&u'(c_1^p) = \alpha u'(c_1^k),\ u'(c_1^p) = \beta R u'(c_2^p),\ \ h'(e)\frac{\partial e}{\partial(e^p+e^k)} > R,\ u'(c_2^p) > \alpha u'(c_2^k),\\
&\text{and } u'(c_1^k) = \beta h'(e)\frac{\partial e}{\partial(e^p+e^k)} u'(c_2^k), \text{where } c_1^p = x^p - g_1 - e^p - a^p,\\
&c_1^k = g_1 - e^k,\ c_2^p = Ra^p, \text{ and } c_2^k = h(e(e^p+e^k,\tau)).
\end{aligned}
\tag{4}
$$

The absence of a second period transfer means that the child has no incentive to behave strategically. As a result, the parent and child agree on the intertemporal condition to be met by the child's consumption: $u'(c_1^k) = \beta h'(e)\frac{\partial e}{\partial(e^p+e^k)} u'(c_2^k)$.

The $g_2 = 0$ equilibrium is inefficient from the family's perspective. The post-schooling consumption that the parent prefers to allocate to the child is less than the earnings produced by the efficient human capital investment. In other words, conditions (4) imply $c_2^k < h(e^*)$, where e^* is the amount of education investment that would make $h'(e^*)\frac{\partial e}{\partial(e^p+e^k)} = R$. If the parent could write a binding contract requiring that the child repay the share of the returns to education necessary to achieve the parent's preferred $c_2^k < h(e^*)$, then, given her full access to credit, the parent would fund the efficient educational investment. However, parents cannot write such contracts.[11] Since parents cannot reclaim the return to e^p invested in the child's education, they

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[10] A knife's-edge case exists where $g_2 = 0$, though $g_2 \geq 0$ does not bind, and at the same time $h'(e)\frac{\partial e}{\partial(e^p+e^k)} = R$. But given incomes, altruism and other model parameters, this case has no consequence for our empirical work.

[11] There are two justifications for this assumption. First, children under 18 cannot enter into binding contracts. Second, because of the assumed power differential between parents and children and possible concerns about practices that may be "contrary to public policy" in the U.S., even if a contract existed, disputes over the contract

invest in human capital to support the child's second period consumption but physical capital to support their own. This leads parents to tolerate the $h'(e)\frac{\partial e}{\partial (e^p+e^k)} > R$ wedge in investment returns, despite their unbounded access to credit. Families in the $g_2 = 0$ equilibrium face no strategic concerns, yet are led by an intergenerational borrowing constraint to invest inefficiently in their children's human capital.

It is this group of $g_2 = 0$ families, where parents are relatively poor, or egoistic, or a child's return to human capital investment falls relatively slowly with additional education, who rationally may choose to not meet their expected family contribution, as determined by the federal rules determining financial aid for higher education.

The next proposition shows financial aid will have different effects on the educational attainment of children in the $g_2 > 0$ and in the $g_2 = 0$ groups. We distinguish between the model's predictions for the price subsidy and lump sum aid cases, but the qualitative prediction is the same: financial aid will have a larger effect on the educational attainment of students in the $g_2 = 0$ group than the $g_2 > 0$ group.

Proposition 2: There are two cases to consider. First, when aid takes the form of a price subsidy, i.e., $e(e^p + e^k, \tau) = (1+\tau)(e^p + e^k)$, and when $g_2 > 0$, $\frac{\partial e}{\partial \tau} = \frac{-h'(e)}{h''(e)(1+\tau)} > 0$. When $g_2 \geq 0$ binds in equilibrium, $\frac{\partial e}{\partial \tau} > \frac{-h'(e)}{h''(e)(1+\tau)}$. Financial aid in the form of a price subsidy increases equilibrium educational attainment for both $g_2 > 0$ and $g_2 = 0$ equilibrium types, but the response is larger in the $g_2 = 0$ equilibrium. Second, when aid is lump-sum, i.e., $e(e^p + e^k, \tau) = e^p + e^k + \tau$, and when $g_2 > 0$, $\frac{\partial e}{\partial \tau} = 0$. When $g_2 \geq 0$ binds in equilibrium, $\frac{\partial e}{\partial \tau} > 0$. Lump sum financial aid does not influence equilibrium educational attainment in the $g_2 > 0$ equilibrium, but it increases equilibrium educational attainment in the $g_2 = 0$

would be unlikely to be upheld in court if a child failed to follow through on their obligation to repay educational loans made by a parent.

equilibrium.

Propositions 1 and 2 formalize our new approach to examining borrowing constraints for education. With data on g_2 and financial aid for specific parent-child pairs, we can examine the correlation between children's years of schooling and financial aid, conditioning on child characteristics, using two separate subsamples. The first is one in which parents make a post-schooling transfer ($g_2 > 0$), and the second is one in which they do not ($g_2 = 0$). Our model implies that financial aid will have a greater effect on children's educational attainment in the second ($g_2 = 0$) sample than in the first ($g_2 > 0$) sample. Indeed, when aid is inframarginal, it will have no effect on children's educational attainment for the $g_2 > 0$ sample but a positive effect on children's educational attainment in the $g_2 = 0$ sample.

To summarize, the model shows the $g_2 = 0$ parent will fail to relieve her child's educational borrowing constraint because she has no means of extracting her preferred share of the return to the efficient educational investment from her child. The $g_2 > 0$ parent, however, can extract her preferred share of the return by foregone post-schooling transfers, so she funds the child's efficient level of human capital investment. Financial aid, therefore, will have a larger effect on the educational attainment of children with $g_2 = 0$ parents than otherwise equivalent children with $g_2 > 0$ parents. Moreover, financial aid will only increase education for children in the latter group in proportion to any price effect created by aid or not at all. Guided by these predictions, we use data from the HRS to examine the extent to which educational attainment responds to financial aid among U.S. students who do and do not receive post-schooling financial support from their families.

e. An Economic Environment with Greater Realism

A skeptic might argue that that our simple model abstracts away from too many important features of reality. Our model is written as if all parents have one child but the theoretical predictions are unaffected by siblings. Recall that the first order condition for human capital investment equates the marginal return to investment in human capital with the real interest rate. With multiple children, the parents will seek to equate marginal returns for every child. It follows immediately that the parent will not give a cash gift to a child (the marginal return of a cash gift is the real interest rate) until the parent has exhausted all possibilities for investment in human capital for every child.[12]

We address additional concerns in Appendix B where we develop a numerical model that incorporates three additional features relevant to our problem. First, in our simple model the two parts of the equilibrium are defined by g_2, second period cash transfers. If income is uncertain, post-college transfers will be affected by income shocks that parents and children receive after the child is out of college, so our sample-splitting strategy will not be sharp. Hence, in the Appendix B model we allow for shocks to earnings. Second, credit card promotions on college campuses are commonplace, so we allow the child to borrow at a higher rate than the parent, rather than not borrow at all. Third, many children work while in college. Consequently, in Appendix B we incorporate a standard production function where time and expenditures are

[12] The key intuition of the theoretical results also carries over in a world where parents' preferences may differ from their children. Suppose, for example, parents value education for its own sake. To fix ideas, let us assume that parents have a utility function of the form $U^p(c_1^p, c_2^p, h^k, g) = u(c_1^p) + \beta u(c_2^p) + \alpha\left(v(h^k) + w(g_2)\right)$, where $v(h^k)$ denotes the utility that the parents enjoy from their child's college education and $w(g)$ proxies for warm glow that parents get from intergenerational transfers. The formulation captures the idea that parents value the child's college education for its own sake. With these preferences and under the assumption that $w'(0)$ is finite, the main proposition in the paper goes through. The intuition behind this is straightforward – if the marginal utility from leaving gifts is low enough and finite, some parents will not want to give gifts until they have exhausted all options for investing in human capital. Pollak (1988) discusses further related considerations.

complementary in producing human capital. This allows us to model a child's decision to work while in college.[13] The model does not have an analytic solution, so we solve it using numerical methods.

For a broad range of utility and human capital production function parameters, we confirm the simple model's central intuition: families who do not pass on post-college gifts to their children are more likely to under-invest in their children's education. Children of parents who make post-college gifts are likely to have received transfers that allow them to reach their efficient level of education. Parents who have the option to make an education transfer and choose not to are foregoing a high rate of return investment opportunity. Since parents are at a point in their lifecycle where they do not face borrowing constraints, the decision to under-invest cannot be rationalized if parents have sufficient resources to make cash gifts later on. For reasonable parameters of the income process, the intuition from the simple model holds probabilistically, but the sample split based on g_2 is no longer sharp.

In the Appendix B model, children of parents who do not make education transfers can borrow, work while in college, or even postpone college. Still, their optimal schooling is less than the efficient level. The reason is that each of these "make do" options are costly. This is obviously true for borrowing at an interest rate that exceeds the financial market rate of return. Working while in college helps relieve borrowing constraints, but takes time away from human capital acquisition as well as leisure.[14] In short, we find that a constrained child who receives no help from his or her parents will, at the margin, consume less, work a little more while in college,

[13] Work while in college is the mechanism children use to relieve borrowing constraints in Keane and Wolpin (2001), for example. They differ from our approach by assuming all children face the same tuition. In contrast, we assume that there are colleges of varying costs and consequently low income families with high ability children will choose to attend less expensive colleges and go to school for fewer years (since time and expenditures are complements), if they are borrowing constrained.

[14] Stinebrickner and Stinebrickner (2003) provide evidence on costs of working while in college.

and choose to go to a lower cost college for fewer years than would an otherwise identical child with more generous parents. Thus, the additional model features we examine mitigate the importance of borrowing constraints, but they do not eliminate their importance.

II. The effects of financial aid on education

The Health and Retirement Study (HRS) has good information on parent-child pairs and post-college transfers. It is a national panel study with an initial sample (in 1992) of 12,652 persons and 7,607 households. It oversamples blacks, Hispanics, and residents of Florida. The baseline 1992 study consisted of in-home, face-to-face interviews with the 1931-1941 birth cohort and their spouses, if married. Follow-up interviews were given by telephone in 1994, 1996, 1998, 2000, 2002 and 2004. Other cohorts, born before 1923 (Asset and Health Dynamics of the Oldest Old), between 1923 and 1930 (Children of the Depression), and between 1942 and 1947 (War Babies), were added to the main HRS cohort in 1998.[15] We use data from all these cohorts as long as needed information is available.

We also make more limited use of data from the NLSY-97, a national panel survey of 8,984 youths who were born between 1980 and 1984, first fielded in 1997.[16] We discuss these data as they are used in our analyses.

a. Measuring post-college cash transfers

In waves 3 through 7 of the HRS respondents are asked the following question about cash transfers exceeding $500 in the last 24 months.[17] The specific wording in 2000 (Wave 5) reads:

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[15] A 1948 to 1953 cohort (Early Baby Boomers) was added in 2004, but because we do not have information on this group in earlier waves, we do not include them in our study.

[16] The earlier NLSY-79 is not ideal for our work because the latest measure of g_2 in that survey was elicited when children were 21 to 28 years old. The ideal measure for identifying parents with active post-schooling financial linkages gathers information over a long post-college period. Moreover, the age distribution of the sampling frame is such that there are too few siblings to estimate models with family fixed effects. The value of conditioning on time-invariant family-specific factors is discussed below.

[17] Wave 1 asks about transfers exceeding $500 in the last 12 months and wave 2 asks about transfers exceeding $100 in the last 12 months.

> "Including help with education but not shared housing or shared food (or any deed to a house), in the last 2 years did [the Respondent or Spouse] give financial help totaling $500 or more to any of their children or grandchildren?"

Those answering "yes" were then asked how much. We aggregate transfers reported by parents over the period 1998-2004 (Waves 4 through 7) for our first measure of post-college cash transfers, g_2.[18] There are three reasons for using this measure. First, starting in 1998 (wave 4) the HRS is a representative sample of all households born before 1948, so it is natural to start with this wave. Second, even if we were willing to ignore data from the new cohorts added to the HRS in 1998, it is not clear how to aggregate over the first three waves due to differences in the way the transfers question was worded in each wave. Third, problems with missing responses increase with the number of waves we use.

We would prefer, however, to use a measure of significant post-college transfers over a longer time period in our empirical work. While no long-term retrospective question on major cash transfers to children is available in any of the HRS core surveys, Wave 2 of the HRS, fielded in 1994, does include a topical module on parent-child transfers. The Wave 2 survey (in Module 7) asked 827 HRS respondents in 427 households:

> "Other than contributions toward education expenses, have you ever given substantial gifts to your grown children?"

Those who answer "yes" are asked the total amount of these gifts. This is arguably the exact question we require to distinguish families with relatively wealthy or altruistic parents who have active post-schooling financial linkages from those with relatively poor or egoistic parents who likely have no post-schooling financial linkages. The drawback to this question is that it

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[18] Recall that the purpose of g_2 is to separate the sample into intergenerationally constrained and unconstrained parent-child pairs. The fact that the primary transfer question includes grandchildren is not ideal, given that the model we write down considers only two generations. But we think parents making cash gifts to grandchildren are likely to have relieved educational borrowing constraints for their children, so we do not view the inclusion of grandchildren in the transfers question to be an important limitation of the study.

was asked only of a small subsample. Thus we report estimates using both the shorter window of cash transfers observed for the full HRS sample and this longer transfer window observed only for Wave 2, Module 7 respondents. Responses to this question are available for 334 of the 9,471 families for whom we have complete demographic and education information on multiple siblings aged 24 and older. These families include 1,262 children.[19]

b. A proxy for financial aid[20]

Financial support for college in the U.S., besides the resources that come from parents, relatives, and the student, come in three primary forms: federally supported grants, federally supported loans, and state and institutional aid.[21] Grants and loans for students pursuing post-secondary, graduate, and professional education were initiated by the U.S. Higher Education Act of 1965. The Higher Education Act was reauthorized every 4 years between 1968 and 1980, and every 6 years thereafter.

It would be difficult to trace and aggregate all of the historical details of U.S. financial aid policy over the relevant period for our sample children, and impossible to uncover parental asset and income information relevant to financial aid formulas at the potential date of college entry

[19] Appendix Table 1 gives more detail on the construction of the full HRS sample and the module sample that we use for our analyses.

[20] We are extremely grateful to Lance Lochner, and to Dan Madzelan of the Department of Education, for sharing detailed correspondence and files on historical US financial aid rules. Additional information is drawn from Baum (1987). Other helpful discussions of federal financial aid policy can be found in NCES (2004), Kane (1998, 2006), Kim (1999), Monks (2004), and Wu (2006).

[21] We do not know the specific college the student attended or the state the student lived in when they attended college or the state the parent lives in at the time of sampling. Consequently, we do not account for institutional/state aid. The aggregate amount of this aid, however, is dwarfed by the aid distributed by the federal formulas, which are the focus of our discussion. Moreover, the types of institutions that have significant amounts of merit-based aid (generally Ivy League schools and some additional private institutions with large endowments) educate a very small proportion of the students that attend college in the U.S. So the omission of private, merit-based financial aid is likely to be a minor omission. States' support for higher education comes largely through allocations to their state university system. They provide relatively little financial aid to students. According to Baum (1987) and the College Entrance Examination Board (1986), state and institutional aid constituted 18, 17 and 23 percent of financial aid to students in 1975, 1980 and 1985, respectively. Some of this state and institutional aid was allocated based on the rules we describe. Almost all of the remaining aid came from the federal programs we described.

for each sample child.[22] One consistent feature of the aid formulas, however, allows us to infer a major component of within-family aid variation from family structure alone. Each major need calculation formula used to allocate financial aid from the leading federal grant and loan programs over the relevant period includes an EFC that decreases sharply as the number of college-going children in the family increases.

The Basic Educational Opportunity Grant (BEOG), a successor (along with the Supplemental Educational Opportunity Grant) of 1965's Educational Opportunity Grant, was established in 1972.[23] In determining a student applicant's eligibility, the formula for the Basic Educational Opportunity Grant calculated the student's family's "Adjusted Available Income" (AAI). The Family Contribution (or EFC) required by the formula was then a proportion of the AAI, and the proportion depended on the number of children the family would have in college in the coming academic year. As an example taken from the application forms for the 1979-80 academic year, a family with one child in college was expected to contribute 100 percent of its AAI toward college costs, a family with two children in college was expected to contribute 140 percent of its AAI in total (70 percent per child), and a family with four children in college was expected to contribute only 160 percent of its AAI in total (40 percent per child). Over the entire sample period, the expected contribution declined steeply and nonlinearly in the number of children in college for all types of need-based federal education grants.

Similar rules apply to loans, though of course, institutional details differ. The Guaranteed Student Loan (GSL) program was established by the 1965 Higher Education Act as the major

[22] Twenty-three percent of children in the underlying dataset attended college in the 1960s or earlier, 37 percent attended in the 1970s, 34 percent attended in the 1980s, and 6 percent attended in the 1990s.
[23] It was renamed the Pell Grant in 1980, but retained the basic structure of the Basic Educational Opportunity Grant.

federal student loan program.[24] While rules determining loan eligibility and amounts have varied over the years, all treated student siblings the same way.[25] For a given student applicant, a family AAI was calculated based on the student's family's income and assets. The EFC was then determined as the AAI divided by the number of children from that family attending college in the relevant academic year. This is also a feature of some forms of campus-based aid.

The objective of federal aid, in cooperation with most U.S. colleges, is to provide grants and loans that cover the cost of attendance after the individual student's expected family contribution is removed, where the cost of attending college for a given student includes tuition and fees, room and board, books and travel expenses. Given the rules determining grant and loan awards, there may be large swings in individual siblings' costs of college as family members age through the education process, which can result in substantial differences in the costs of educating siblings within the same family.[26]

We use the variation in college financial aid due to children's birth spacing to proxy for unobserved aid levels.[27] The median year in which children in our HRS sample reach the age of 18 is 1977, with most being college age in the 1970s, 80s, and early 90s. The landmark 1965 reforms in higher education finance occurred *after* the vast majority of children in our sample were born, so decisions about birth spacing were very unlikely to be affected by financial aid considerations.

[24] The program was renamed the Stafford loan program in 1987.

[25] Broadly speaking, there have been three sets of rules governing the allocation of guaranteed student loans. From 1965 to 1974, loans were allocated based on third-party need analysis formulas "approved" by the Department of Education. In 1974, these third-party formulas were formalized as the Uniform Methodology. In 1986 the Uniform Methodology was replaced by the (similar) Congressional Methodology, which was controlled by the Department of Education. Finally, along with many other reforms, the 1992 HEA merged the need formulas determining grant and loan eligibility into the Federal Need Analysis Methodology.

[26] For example, for many years of the sample, $EFC=AAI/N$, where N is the number of children in the family attending college.

[27] Our use of child birth spacing is similar to the approaches taken by Kim (1999) and Monks (2004) to estimate the savings effects of the asset tax implicit in the federal financial aid formula.

A natural question to ask is whether sibling overlap is significantly, positively correlated with financial aid. We cannot examine the relationship between sibling overlap and financial aid using the HRS because it does not include information on financial aid. But we can examine the relationship using the NLSY-97. To do this we regress the financial aid a student received in his or her first term of college on a set of covariates, including parental income, parental income squared, net worth, net worth squared, AFQT, AFQT squared, a constant, and a measure of sibling overlap. We measure a point-in-time sibling overlap variable as the number of siblings who are college age (ages 18 through 21) at the time financial aid is being measured for the child in question.[28] The sibling overlap variable does not require the sibling to be in college at the time, since this information is not available in the HRS.[29] The coefficient of the overlap variable given in Appendix Table 2 is $358 and it is significant at the 5 percent level.[30] This result, along with evidence from Liu and van der Klaauw (2007), adds to our confidence that the financial aid proxy used in the HRS analyses does, in fact, capture financial aid differences within and across families.

Given that parental resources affect financial aid, families might want to declare their children's financial independence. The standards for independence, however, are strict. In order to declare independence a student must *(i)* reach age 24 by January of the academic year, or *(ii)* enroll in a graduate program, or *(iii)* be married, or *(iv)* have a dependent child or other dependents, or *(v)* be an orphan or ward of the court, or *(vi)* be a veteran of the U.S. Armed

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[28] We used the household and non-household rosters to construct information on respondents' siblings (so that we could get siblings living both in and out of the respondent's home). Siblings are defined to be biological, half, step, adoptive, or foster siblings. Our measure of financial aid includes the dollar amount of any grants, scholarships, loans, work study, or other kinds of government/institutional aid a respondent received during his/her first term of post-secondary schooling.

[29] Another reason the overlap proxy relies on potential and not actual overlap in college attendance is because realized overlap or a siblings' realized college attendance while the child is 18-21 would be mechanically related to our outcome variable of interest, educational attainment.

[30] The mean financial aid for all NLSY-97 college students is slightly under $3,000.

Forces (IFAP 2006). Thus a child under age 24, whose parents decide not to make the expected family contribution, will need to cut back their schooling, work while in college, stretch out the time they are in college, or find some other way to adapt. As discussed earlier, all these adaptations lower the net returns to schooling so, as argued in Appendix B, the implications of the model still hold.

c. Estimation samples and covariates

Our sample selection criteria include the requirement that we observe parents' household income and net worth and complete information on the education, date of birth, and relationship to the family of each child reported by the HRS respondent. We also require that children included in the estimation have at least one sibling (this drops 1,502 one-child households). Finally, we include only children aged 24 or older (in 2000) in our estimation sample. The intention of this restriction is to allow the sample children time to complete their schooling, and to consider only cash transfers that take place following completion of the children's' schooling.[31] This leaves us with a sample of 34,593 children from 9,471 HRS families.

Our empirical models include child variables that allow us to condition on factors that may influence the schooling attained by a young adult student, particularly relative to his or her siblings. These include the child's age in 2000, the child's gender, indicators for whether the child is an oldest or youngest child, and a cumulative measure of sibling-years of overlap for a college-age child. Specifically, the child's sibling-years of overlap is the sum of the number of siblings the child had between the ages of 18 and 21 while he or she was 18, plus the number of siblings aged 18-21 while he or she was 19, and so on, until the child is age 21.[32]

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[31] The qualitative results are similar if we require sample children to be aged 30 or older in 2000.

[32] Triplets, for example, each have eight sibling-years of overlap in college ages. A child with two siblings who are three and six years younger, respectively, has one sibling-year of overlap in college ages. The middle child in this family has two years of overlap, and the youngest child has one.

Table 1 gives descriptive information for these variables for both the full HRS analysis sample and for the Wave 2, Module 7 respondents. Forty-nine percent of core sample children have parents who made positive cash transfers to them or to a sibling between 1998 and 2004, and 37 percent of the children of module respondents have parents who ever made substantial non-educational transfers to their adult children.[33] These variables allow us to split samples based on post-schooling transfers as suggested by the analytic model. Roughly half of each sample is female. The median child age in 2000 is 41 for both samples. Birth order indicators tell us that 29 (26) percent of core (module) sample children are oldest siblings, 26 (24) percent youngest, and 45 (50) percent are middle siblings. We exclude any variables that were likely determined after the completion of the child's schooling, such as marital status or earnings in 2000.

The dependent variable in our primary empirical specification is the child's education. Core sample children have attained a mean of 13.8 and a median of 13.0 years of schooling (it is 13.3 and 12.0 in the module sample). The large sample and broad range of ages give us a standard deviation of 6.88 years of schooling, despite the top-coding of schooling years to 17 for graduate and professional education.[34] The primary independent variable of interest is years of overlap with siblings. Its mean and median are 2.34 and 2.00 in the core sample and 2.63 and 2.00 in the module sample. There is substantial variation in sibling-years of overlap in both samples, with a standard deviation for this variable of roughly 2.1 years in each.

[33] Readers might expect that the fraction of the sample *ever* giving cash gifts would exceed the fraction of the sample giving cash gifts between 1998 and 2004. Three factors make the 49 and 37 percent responses not comparable. First, the Wave 2, Module 7 question refers to "substantial" gifts while the other question asks specifically about gifts exceeding $500. Second, the Wave 2, Module 7 question is asked of a much narrower cohort of households. Third, the core sample question includes gifts to grandchildren exceeding $500.
[34] The youngest children in the sample are 24. The oldest 1.8 percent of children have reached retirement age.

III. The empirical model, results, and robustness

Many factors likely influence the difference in schooling between two arbitrarily chosen, unrelated students. Among other issues, parents may differ in their attitudes toward education and the investments they make in their children. Heritable components of academic aptitude that the students received from their parents might also differ. We would have a difficult time controlling adequately for these between-family differences using the HRS data. We therefore examine the implications of Proposition 2 by making within-family comparisons, examining the educational attainment of closely-spaced siblings (who are expected to get more financial aid) relative to the educational attainment of siblings spaced further apart (who are expected to get less financial aid). Moreover, we expect the effects of financial aid to be larger for children who come from families who go not make post-college transfers $(g_2 = 0)$ than for those that do $(g_2 > 0)$.

Our empirical model is:

$$e_{is} = \omega_i + X_{is}\beta + \gamma o_{is} + \varepsilon_{is}, \tag{5}$$

where families are indexed by $i = 1,\ldots,N$ and siblings in family i by $s = 1,\ldots,S_i$.[35] In this expression e_{is} represents the education of sibling s in family i, X_{is} is a vector of exogenous characteristics of sibling s in family i, and o_{is} represents the number of years of overlap in college ages that sibling s in family i shares with his or her siblings. The family fixed effect ω_i represents the unobservable contribution to educational attainment shared by the children of family i, and accounts for the effect of family wealth and other characteristics that do not vary within the family. Because siblings in two-child families will have identical overlap, γ is

[35] The number of siblings varies from 2 to 11 across families, creating an unbalanced panel.

identified directly by families with 3 or more children. Most parent-child pairs remain in the sample for our empirical work. More than 57 percent of families in the HRS have 3 or more children, about 80 percent of the parent-child pairs in our sample come from families with 3 or more children. Two-child families, of course, help identify coefficients on other covariates in the empirical models and since the sibling overlap coefficient estimate is determined jointly with all of these other coefficients, two-child families contribute indirectly to the identification of the sibling overlap coefficient.

The main coefficient of interest is γ, the effect of the overlap variable (which proxies for financial aid) on children's total schooling. A question arises, however, about why we focus on financial aid instead, for example, on more general resources that improve the income of the parent. In particular, whenever $e^p > 0$ at the initial τ, the parent has chosen a level of educational investment that exceeds the amount of financial aid. If aid came in the form of a financial transfer to the parent rather than through τ, the parent would choose the same net educational investment. The interesting case for our paper, therefore, occurs when $e^p = 0$ at the initial τ, since in this case the allocation between τ and x^p will affect equilibrium education. This is an empirically important case. When $g_2 = 0$ and we can see e^p (that is, the child attended some college), $e^p = 0$ 54 percent of the time for at least one child in the family.

Given that parents do not face borrowing constraints in the model, it may seem curious that we focus on the overlap of the child in the specific parent-child pair, rather than the general overlap of all siblings. When $g_2 = 0$ and $e^p = 0$, however, the parent and child are intergenerationally constrained – indeed, if anything, the parent would like to borrow against the child's resources but cannot do so due to their inability to write a binding contract with their child. As noted above, for the no-gift $(g_2 = 0)$ sample, among those families where at least one child got some college or more, 54 percent of families have at least one child with some college or more and $e^p = 0$. For these families, a closely spaced sibling in college does not generate resources that can be used by a sibling 5 years younger, since the parent cannot crowd out financial aid with a further reduction in private parental transfers. Consequently, the constrained parent is unable to move around resources from twins, for example, to assist a younger child.

Table 2 reports estimates for the gift and no-gift subsamples using the full HRS sample and the special question asked of Wave 2, Module 7 respondents. We find a coefficient on overlap of 0.105 in the no-gift, full HRS sample, which is significantly different from zero at the one percent level.[36] The corresponding coefficient in the gift, full HRS sample is 0.034. The estimate is not significantly different from zero at standard confidence levels. A similar pattern emerges in the results using the Wave 2, Module 7 sample. The coefficient on overlap in the no-gift sample is 0.094 and differs significantly from zero at the one percent level. The coefficient on overlap in the gift sample is -0.050 and is insignificant.[37]

The overlap estimate of 0.105 implies that a twin with no other siblings in a family that does not make post-college transfers will complete, on average, 0.42 years more schooling than an otherwise equivalent only child, all else equal. The estimate applies to the specific child in the parent-child pair. To help assess the economic importance of these estimates, consider the following calculation. Assume that the child has two parents, one of whom worked and earned

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[36] To the extent there is error in our sample-splitting strategy, as would occur, for example, in the numerical model in Appendix B, the size of the estimates and power of the tests will be reduced. Guo (2007) provides a straightforward proof.

[37] In simultaneous estimation of all group-specific coefficients for the gift and no gift samples, F-tests reject the null hypotheses that the gift and no gift overlap coefficients are the same for the full and module samples at the ten and six percent levels, respectively.

the 1983 median U.S. household income of $20,885.[38] We assume that students first get whatever Pell grants they are entitled to, based on rules from the Pell Grant Index that applied to the 1984-85 academic year. Remaining unmet need is then met through Guaranteed Student Loans and campus-based aid, which is allocated based on applicable rules. We assume the student attends an average-cost 4 year, public, in-state institution. Total annual tuition, fees, room and board, based on figures from the National Center for Education Statistics, were $3,682 in 1984 dollars. Over four years of college, the difference in total financial aid offered to two otherwise identical students, one with a twin attending college and the other with no siblings attending college, is $1,728 in 1984 dollars, which is $3,568 in 2009 dollars. Thus, we infer on average that $3,568 (in 2009 dollars) of additional financial aid would result in 0.4 additional years of educational attainment for a student whose family does not make post-college transfers.[39] Of course, not all students appear to be intergenerationally constrained. Further, it would be very difficult to offer aid exclusively to intergenerationally constrained but not to intergenerationally unconstrained students. About half the sample is in the "no gift" group. Hence, we infer that the overall effect of an increase in available financial aid of approximately $3,600 to all students would led to an average increase of 0.2 years of final educational attainment.

We can assess the plausibility of this estimate making use of a simple calculation of the rate of return to additional financial aid. As inputs we need estimates of the lifetime earnings of the HRS cohort's children, the return to schooling, and the costs (including opportunity costs) of

[38] The detailed financial need formulas (and the tax calculations they necessitate) require several other assumptions regarding family characteristics. We assume that the child has assets that do not exceed asset exemption thresholds, is dependent on their parents and receives no Social Security or Veteran's education benefits. We assume that parents have assets that do not exceed the exemption thresholds, pay average state taxes given their income level, make no IRA/Keogh contributions, and have no other untaxed income, excessive medical expenses or primary or secondary tuition expenses.

[39] This figure is nearly identical to that implied by the estimates in Appendix Table 2. The estimate of $358.44 multiplied by 8 semesters is $2,868 in 2000 dollars, which is $3,573 in 2009 dollars.

education. We find the return to this investment is around 17 percent.[40] Given the deadweight loss of taxation and the uncertainty associated with the investment (returns, for example, surely vary by type of major), the rate of return calculation supports the plausibility of the estimates.

Proposition 2 suggested that aid could have a positive effect on educational attainment even in the sample of parent-child pairs where parents made post-college gifts. A key question is whether the last dollar the family invests comes from the family or comes from financial aid. If it comes from the family, aid is a lump sum transfer and we would expect no effect of overlap in the $g_2 > 0$ sample. If it does not come solely from the family, aid would be expected to increase educational attainment, but by not as much as in the $g_2 = 0$ sample. We do not know the relative prevalence of the two forms of aid in the data, but the fact that we get little or no estimated aid effect for the unconstrained families suggests that the inframarginal aid case better characterizes the data for the $g_2 > 0$ sample.[41]

Other coefficients in Table 2 reflect the correlations between children's demographic

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[40] Financial aid for a twin (relative to a child with siblings spaced 5 or more years apart) is $1,700 in 1984 dollars. This subsidy leads children from constrained families to acquire 0.4 more years of schooling. Assume a real interest rate of 5 percent and a rate of return to education of 8 percent. The annual Tuition and required fees was $2,567 (excluding room and board) in 1984-85 (National Center for Education Statistics http://nces.ed.gov/programs/digest/d08/tables/dt08_331.asp). In the presence of a subsidy of $1,700, the student chooses to go to school for an extra 0.4 years. Consequently, the student will pay additional tuition and also bears the opportunity cost of going to school for an additional 0.4 years. Using cross sectional annual earnings information from the Current Population Survey, we construct a 40-year age-earnings profile for a hypothetical average child. The implied return to investing in the constrained child is 33 percent. The government, of course, cannot distinguish constrained from unconstrained children, so the return to the generic, average financial aid dollar would be roughly half the return to the constrained child. Even this likely is an overestimate since college education is heavily subsidized and the student does not pay the true marginal cost associated with an additional year of schooling.

[41] The financial aid proxy in the full sample results is almost always positive, though imprecisely estimated in the $g_2 > 0$ (unconstrained) subsample.

As a further check on our arguments, we estimated the model of Table 2 with two additional subsamples, those where $g_2 = 0$ and $e^p = 0$ and those where $g_2 > 0$ and $e^p = 0$. We expect the overlap coefficient to be larger and even more significant in the first subsample than in the Table 2 (no gift) sample, despite the smaller sample size (since we eliminate families that might undo financial aid given to closely spaced siblings). We continue to expect no (or undetectable price) effects for the second subsample. Strikingly, this is precisely what we find. The overlap coefficient for the first subsample is 0.146, with a t-statistic of 4.11. The overlap coefficient for the second subsample is -0.037 with a t-statistic of 0.78.

characteristics at the time of schooling decisions and their educational attainment. Brothers get less schooling than their sisters on average, and this effect is significant at the five percent level in two of the samples. The implied difference in schooling between brothers and sisters on average is a third of a year or less. Controlling for birth order, older siblings get significantly less schooling than younger ones in both no-gift samples; one year more of age is associated with 5 hundredths of a year of school in the two samples. Oldest children receive more education than their middle-child siblings on average, though the estimated coefficient on the oldest child indicator is significantly different from zero for only one of the four samples. There is no clear pattern in the level of schooling of youngest children relative to those of middle children.

Before describing our robustness checks, we briefly mention two less far-reaching specification and sampling alternatives.[42] First, we recognize the coefficient estimates on gender, age, and youngest and oldest child indicators vary across samples in magnitude and significance. Specifications where we exclude all within-family covariates except the family effect and the overlap measure also yield a positive and highly significant overlap coefficient for the no gift group and a small, insignificant overlap coefficient for the gift group. So the key result in Table 2 is not sensitive to the inclusion of covariates. It also does not depend on whether or not step-children are included in the sample. Several authors have noted that parent-child behavior and outcomes can differ for stepchildren relative to biological children of either parent.[43] We repeated the central estimation shown in Table 2 using only never married parents and parents who were still married to their first spouses in 2000 in an effort to drop step families. The results for the parameters of interest were very similar.

[42] Any result not shown in the paper is available from the authors on request.
[43] See, for example, Light and McGarry (2004), Brown (2006), and Pezzin, Pollak, and Schone (2006).

b. Estimation issues and sensitivity analyses with the HRS sample

In the remainder of this section we describe six sampling or robustness checks that increase our confidence that we are interpreting the empirical results sensibly. While we elaborate on each in greater detail below, we can roughly break the discussion into a) who is being affected – here we make sure the affected groups are, in fact, children who could plausibly be affected by financial aid; and b) is it something else – here we try to rule out spurious explanations for the results.

1. Who is being affected? The distributional effects of financial aid policy

There are nonlinearities in the financial aid system that we do not account for in the equation (5) empirical model. In particular, the children of very wealthy parents should expect no federal financial aid whether or not they have siblings in college (also see Monks, 2004). Similarly, federal aid formulas provide approximately full support to the children of very poor parents, and therefore educational achievement should be unrelated to sibling overlap. Thus, even in the no-gift subsample, we might expect years of schooling to be unresponsive to sibling overlap for children in low-income families, because they receive full financial aid, and for children in high wealth families, because there will be no differences in schooling costs across children (within a family) due to financial aid considerations.[44]

[44] Before the Middle Income Student Assistance Act in 1978, students with family incomes above $15,000 were ineligible for Basic Educational Opportunity Grant (Pell grant) funding. Median U.S. family income in 1978 was $15,064, so students with family income above the median had limited access to federal grant-based aid. The Middle Income Student Assistant Act expanded Basic Educational Opportunity Grant (Pell grant) aid beyond the $15,000 cap. However, in the 1979-80 academic year, roughly 80 percent of Basic Educational Opportunity Grant (Pell grant) dollars went to students with family incomes below the median. The Pell program favored lower income students even more in subsequent years, with roughly 95 percent of academic year 1983-4 Pell grant dollars going to students with family incomes below the median. Given that 33 percent of U.S. college students received Pell grant aid in 1980, and that 38 percent of the High School and Beyond (a nationally representative education dataset) seniors in 1980 who attended college came from the lower half of the family "socioeconomic status" distribution (17 percent from the first quartile), it seems reasonable to characterize access to federal grant aid for low income students as extensive in the late 1970s and early 1980s (these figures come from Baum, 1987, the Statistical Abstract of the United States 1985, and information from the College Entrance Board) .

To address the concern about non-linearities, we repeat the initial estimation, but this time estimate separate overlap coefficients for each parental net worth tercile. Estimates are given in Table 3 using the full HRS sample and a sample based on the special question asked of Wave 2, Module 7 respondents. The estimated overlap coefficients are small and not significantly different from zero for each of the net worth terciles of both gift samples. In the no gift samples, we find small, insignificant overlap coefficients for the poorest and wealthiest terciles. However, the significant (at conventional level) point estimates on sibling overlap are 0.189 for the middle tercile of the full HRS sample and 0.197 for the much smaller special module sample. F-tests reject the null hypotheses that the middle tercile coefficient is equal to the high and low tercile coefficients at the five and ten percent levels, respectively in the full sample (but only rejects the equality of the middle and high coefficients in the smaller module sample).

Parental net worth, observed when children are, at the median, 40 years old, is clearly an imperfect measure of parental income and net worth while the child was in school. Some children whose parents' net worth is in the bottom tercile presumably did not receive aid, while some children whose parents' net worth is in the top tercile perhaps did. We nevertheless believe this specification is useful in helping us understand whether the Table 2 sibling overlap results are driven by something other than financial aid. Given the extensive aid available to low income students when the bulk of our sample was college age, and the manner in which aid availability phased out for higher incomes, we would be suspicious of estimated sibling overlap effects on educational attainment that were as strong for students from bottom-tercile or top-

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Other forms of student aid were available, to some degree, to students with family incomes above the median. Prior to the Middle Income Student Assistance Act, the cap on family income of $25,000 for Guaranteed Student Loan aid was located at roughly the 80th percentile of the U.S. income distribution. The cap was relaxed following the Middle Income Student Assistance Act, leading to a more than tripling of Guaranteed Student Loan aid. Roughly 41 percent and 37 percent of campus-based work study aid dollars went to students with family incomes above the median in the 1979-80 and 1982-3 academic years, respectively.

tercile families as they were for students from more representative families. But this is not what we find. The evidence that the effect of sibling overlap on educational attainment is strongest for middle wealth families in two samples is encouraging, given the structure of financial aid policy.

2. Who is being affected? Historical changes in financial aid policy

Financial aid to middle and higher income families increased substantially in 1978 as a result of the Middle Income Student Assistance Act (MISAA). Before the MISAA, the Pell Grant and Guaranteed Student Loan (GSL) family income caps were $15,000 and $25,000, respectively. The U.S. median household income in 1978 was $15,064. The MISAA extended both types of aid to children of families with higher incomes, and was followed by a tripling in the number of GSL program loans over 3 academic years.[45]

With more aid available for middle-income children as a consequence of the MISAA, we expect the main beneficial effects on attendance to occur for those children who now have greater access to aid, but whose parents, for one reason or another, were not fully committed to paying for college. In the context of the Table 3 empirical specification, we expect the interaction of overlap and the middle wealth tercile to be larger (while still positive and significant) following the MISAA than before enactment of the MISAA. We further expect the MISAA to have smaller or no beneficial effects on attendance for the $g_2 > 0$ subsample (though parents presumably benefit from inframarginal subsidies).

We split the sample into a pre-reform subsample that includes only students who reached age 18 in 1978 or before, prior to the bill passage and expansion in aid. The post-reform subsample includes only students who reached age 18 in 1979 or later, after the aid expansion. Estimates for the Table 3 empirical model, pre- and post-reform, are given in Table 4.

[45] Further detail on the short-run effects of this and other aid reforms can be found in Baum (1986).

As expected, the coefficient for the overlap by middle wealth tercile interaction is precisely estimated and larger – nearly twice the size – in the post-reform subsample as in the pre-reform subsample. Hence the expansion of aid to families above the median income following the MISAA is accompanied by a shift in the estimated association between the aid proxy and attainment of children in middle wealth families.[46]

As in the previous specification, the overlap by high-wealth interaction is insignificant in both groups both pre- and post-reform. In addition, five of six coefficients in the $g_2 > 0$ subsample are insignificant, as expected. We find two unexpected results in Table 4, both occurring for the pre-reform sample for the overlap-by-lowest-wealth-tercile coefficients. The positive, significant coefficient for the low-wealth, no-gift pre-reform subsample might suggest that aid was scarce even for low-wealth (and income) children, so having a closely spaced sibling enhanced the ability to finance college relative to observationally similar children without a closely spaced sibling. A potential explanation for the *negative* significant coefficient for closely spaced siblings in families who made post-college gifts arises from the fact that the Basic Educational Opportunity Grant was limited to half of the cost of college when it was implemented in 1972, and no supplemental grant program existed to cover the residual. Hence students whose need profiles qualified them for full Basic Educational Opportunity Grant aid without the presence of a sibling might not be aided, and might in fact be hurt, by a sibling entering college around the same time and competing for family resources.

<u>3. Who is being affected? The attainment margin should be related to college</u>

Many children in our samples were born in the late 1940s and 1950s. A high school degree for this cohort was less common than it is today. Our preferred interpretation of our results

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[46] The coefficients also reflect the fact discussed by Kane (2006) and Belley and Lochner (2007) and others that the real cost of college has risen sharply while federal financial aid has not kept pace.

would clearly be wrong if the margin through which education increases for closely-spaced children in the no-gift sample is that they were more likely to get to 11th grade rather than 10th grade. Put differently, college financial aid should have its primary influence on *college* enrollment and attainment.

When we exclude high school dropouts, we get similar results for the association between overlap and educational attainment, with the exception that the positive, significant overlap coefficient in the no-gift sample is substantially larger.[47] As in Kling (2001), we find that the response to our schooling cost measure is greatest at the college entry margin.

4: Is it something else? Ability and birth spacing

We do not have an ability measure in the HRS. This is one of the reasons why a within-family (fixed effect) specification is useful, since it accounts for time-invariant, family-specific ability differences that might arise from the home environment. Nevertheless, there are obviously ability differences between children within a family. If closely spaced children have significantly different ability than children with greater birth spacing, our HRS-based estimates might be biased. For this bias to explain most or all of the results, it must be the case that the ability levels of closely spaced children exceed the ability levels of children spaced apart in families where there are no post-schooling transfers (constrained families, or families with $g_2 = 0$), and this ability differential with birth spacing does not occur in unconstrained ($g_2 > 0$) families. If families with closely spaced kids are resource-constrained over their life-cycle, either in the time or the money they are able to allocate to closely-spaced siblings, it seems unlikely the constrained subset have higher ability children relative to others, at least in an economically important magnitude.

[47] We used a conditional logit specification to estimate the effect of sibling overlap on high school completion in samples and specifications otherwise identical to those in Table 2. We found no significant association between sibling overlap and high school completion for either the gift or the no-gift samples.

We can shed a little further light on this potential explanation using data from the NLSY-97: in particular, we look at whether sibling overlap is correlated with AFQT. In Appendix Table 3 we show the result of regressing AFQT on sibling overlap and covariates that we expect to be correlated with AFQT, including mother's education, parental income, parental income squared, indicator variables for the number of siblings, female, black, Hispanic, broken home, living in an urban area, and living in the South. Sibling overlap is significantly correlated with AFQT, but the relationship is negative, and the empirical magnitude is -0.51, while the standard deviation of AFQT is 29.2 in the sample. Hence, we find it implausible that unobserved ability accounts for the empirical patterns we document in the HRS data.

5: Is it something else? The role of altruism

Underlying family characteristics – parental resources, the shape of the human capital production function, and altruism – will determine the region of the parent-child equilibrium. One unusual feature of the HRS is that it includes, for a small subsample, self-reported measures of parents' financial generosity toward their children. Wave 5 of the HRS from 2000 contains an Economic Altruism Module where parents were asked

> "Suppose that [your child/one of your children] had only half/three-quarters/one-third as much income per person to live on as you do. Would you be willing to give your child 5% of your own family income per month, to help out until things changed – which might be several years?"

Our analytic model shows that post-college giving will be more common among parents with higher α values. If the responses to the special HRS module question are informative about α, we expect financial aid to have a smaller effect on the educational attainment of children with high-α parents than those with low-α parents.

914 parents (with 3,292 children) responded to this question and have complete information on other covariates included in our empirical model. Only 3 percent of children had parents who

said they would give at 1/3 but not above. So we pool the 1/3 respondents with those who indicate that they would not give 5 percent of their income under any of the scenarios.

We estimate the empirical model given in (5), modified so that

$$e_{is} = \omega_i + X_{is}\beta + \sum_{j=1}^{3} \gamma_j m_j o_{is} + \varepsilon_{is}, \qquad (6)$$

where indicators $m_1 = 1$ if the parent gives under no circumstances or only when the child's income is 1/3 of hers (12 percent of the sample), $m_2 = 1$ if the parent gives when the child's income is ½ of hers but not when it is ¾ (26 percent of the sample), and $m_3 = 1$ if the parent gives when the child's income is ¾ of hers (62 percent of the sample).

The estimates are presented in Table 5. The overlap coefficient is insignificant (with a t-statistic below one) for the most altruistic families: those who will give 5 percent of their income when their child's person-adjusted income is ¾ of theirs. The overlap coefficient is large, positive and highly significant for each of the less generous parent categories. F-tests fail to reject the null hypothesis that $\gamma_1 = \gamma_2$ but strongly reject the null that $\gamma_1 = \gamma_2 = \gamma_3$. To the extent that high self-reported generosity is predictive of the giving equilibrium, these results also align with the model and our previous results in that financial aid is inframarginal for children of the most altruistic parents but that it matters for the children of other parents.

Bequests are another type of post-schooling transfer. We observe relatively few actual bequests in our data. But in a similar altruism module fielded in 1994 (Wave 2, Module 7), a subset of HRS parents were asked whether they thought "leaving a significant estate for grown children" was "very important, somewhat important or not at all important." When we estimate the Table 5 altruism model, but replace the previous altruism measures with indicators for whether or not parents thought it was very important to leave a significant estate, the estimated overlap coefficient among students whose parents did not think it very important to leave a significant estate is 0.186 and significant at the 1 percent level. The overlap coefficient among students whose parents did think leaving a significant estate is very important is 0.055 and not significantly different from zero. We also used the bequest measures available to us for living parents in the HRS 2000 core sample. Parents were asked the probability of their leaving a bequest of $100,000 or more.[48] Using the set of HRS 2000 core families who had complete responses, the overlap coefficient for students whose parents expect to leave a bequest of $100,000 or more is 0.047 and is not significantly different from zero. For students whose parents do not expect to leave a bequest of $100,000 or more, the overlap coefficient is 0.109 and is significant at the one percent level. The estimated differences in the effect of the financial aid proxy by whether parents appear likely to leave bequests works precisely in the expected direction.

6. Additional evidence from the NLSY-97

We do not have data on e^p in the HRS data. The NLSY-97, however, does have this information, which allows us to examine two additional implications of our analytic framework. First, when parents make no contribution to college and their expected family contribution is positive, borrowing constraints imply the probability of completing college should *decline* with parental income. This expected empirical pattern is precisely the opposite of the positive college-income gradient that many previous studies interpret as being consistent with credit constraints.

We impose four sample restrictions to look at this hypothesis. First, parents make no

[48] Where both parents responded to the bequest question, we take the answer from the financial respondent for the household.

contributions for college ($e^p = 0$);[49] second, parental income in 1996 exceeds $20,000 (in 2004/05 dollars); third, all children in the sample have enrolled in at least one semester of school beyond high school; and fourth, no covariates or variables to select the sample are missing. The first criterion is necessary to yield an unambiguous empirical hypothesis.[50] The second criterion is necessary because, below some threshold of income, the expected family contribution is zero. As long as institutions meet financial need through packages of grants and loans, parents with very low incomes would be expected to make no contribution to their children's higher education, yet their children would not be borrowing constrained. Twenty thousand dollars (in 2004/05) is a conservative threshold below which the parent's expected family contribution is $0.[51] The third criterion arises because we select the sample on the condition $e^p = 0$. It is trivially true that parents provide no payments for higher education when their children never attend college. But these children may well not be intergenerationally constrained. To examine the sharp hypothesis of a *declining* relationship between income and college completion, we want to focus on families that are intergenerationally constrained. Descriptive statistics for the samples and details on the sample construction are given in Appendix Tables 4 and 5.

Table 7 reports the marginal effects from a Probit regression on college completion. Parental income is indeed negatively related to college completion for incomes up to $112,000, which includes 97 percent of the sample. Evaluated at the means of continuous variables and modes of discrete variables, a $10,000 increase in income lowers the probability of college

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[49] Parental support for college (e^p) is positive for a given college term when the respondent indicates that one or both of her parents provided financial assistance during that particular term (through 2004). Respondents with college experience whose parents do not provide assistance during *any* of the terms they are in college compose our sample of $e^p = 0$ students.

[50] The expected relationship between income and educational attainment in the $e^p > 0$ subsample is ambiguous. Financial aid will decrease with income, but parental gifts presumably increase with income.

[51] The guidelines state that the EFC should automatically be zero if gross income is under $15,000. With exclusions and other provisions, there is clearly a discrepancy between our NLSY-97 income measure and "gross income" as required in EFC calculations.

completion by 1.7 percentage points. This marginally significant result is consistent with the existence of borrowing constraints for higher education. The coefficients of other covariates have the expected signs, but only the coefficients of female (which is strongly, positively correlated with college completion), AFQT and student age are significant at usual levels of confidence.

The second test is based on the following idea: Our theory and empirical work emphasize the importance of identifying the potentially constrained population, namely those parent-child pairs where the parents do not invest efficiently by meeting their EFC. Up to this point we have followed the implications of the theory, distinguishing the constrained group by whether or not parents make post-schooling gifts. An alternative we can pursue with the NLSY-97 is to impute the EFC directly and then observe whether parents paid it based on reported contributions.

The EFC is a function of many factors including parents' income, assets, and family structure. We expect the child's years of education to decrease with $(EFC - e^p)$. There are two issues that arise with this alternative approach. First, the factors that determine the EFC are complex (in recent years, for example, there were 28 distinct income and asset items that go into the EFC calculation). So estimates of $(\widehat{EFC} - e^p)$ will likely be biased, since we do not have the information needed to accurately calculate EFC. Second, credit constraints may also affect whether or not a child goes to college. But we have no measure of e^p for a child who does not attend college. Hence, the second new robustness test is not our preferred approach.

Nevertheless, we can use data from the NLSY-97 to construct an estimate of the parents' EFC. To do this, we incorporate the following assumptions. First, we use 2001-02 academic year financial aid rules. Over the relevant period covered in our data, there are few changes to the rules (beyond adjusting for inflation). Second, we use parental financial information from

1997 (in 2000 dollars), since these are the primary data collected by the NSLY-97 on parental resources. Third, we use the income of the custodial parent's household rather than the income of the biological parents, in cases where the child does not live with his or her biological parents. We do not have information on the non-custodial parent's resources, though the EFC calculations seek information on these. Fourth, we impute tax liabilities making use of the NBER's TAXSIM model (Feenberg and Coutts, 1993), which requires us to make assumptions about property taxes, mortgage interest, and state of residence, among other things.[52] Fifth, and perhaps most importantly, we assume the EFC calculation is based on the average cost of a child attending an in-state, four-year public university, while living at home. The choice of college is clearly endogenous to the parents' willingness to finance education. Consequently, we believe the costs of college are conservatively proxied by the average in-state tuition and fees for 4-year public institutions. The figure (in 2006 dollars) in academic year 2001/02 was $4,326 (College Board, 2006).

The key covariate in our empirical model of the highest grade completed is $(\widehat{EFC} - e^p)$. As discussed above, the maximum EFC is capped at the in-state public college cost. The minimum value of $(\widehat{EFC} - e^p)$ is set to zero: parents who give larger gifts than our imputed EFC are simply considered to have met the full EFC, but not more. Other covariates in the empirical model include parent income and its square, net worth, AFQT, number of siblings, and indicator variables for the child's gender, race and ethnicity, child age, mother's education, and whether the child lives in a single-parent household, in an urban area, or in the South.[53]

[52] We assume property taxes are $9 for every $1,000 of home value, mortgage interest is 6 percent of the outstanding mortgage balance, and the household is living in an unspecified state in TAXSIM, which results in the household receiving roughly average state income tax liabilities.

[53] This is a richer set of covariates than what is included in the central HRS-based specifications. But the HRS-based models include family-specific effects.

Results for a specification focusing on highest grade completed are given in Table 8. The key coefficient estimate is for $(\widehat{EFC} - e^p)$: it is negative and significant at the one percent level. Its magnitude suggests that a child from a well-to-do family who is expected to meet the full cost of the in-state public university but who, for one reason or another, decides to give nothing, would get roughly 0.6 years less total schooling than an otherwise identical child whose family meets the full EFC. This result is again consistent with borrowing constraints for education being an economically important phenomenon for a non-trivial portion of parent-child pairs. Substantially fewer than half the families in the sample used in Table 8 meet their full EFC. More than forty percent of children in the sample have gaps exceeding $1,000 between estimated EFC and parents' actual contributions.

The other covariates in the empirical model conform to expectations. The highest grade completed is positively related to AFQT, being female, and being black, and negatively related to the number of siblings, being from a single-parent home and being younger at the time of the initial NLSY-97 interview.

7. Summing up

We develop an analytic model that tells us precisely how to approach the data to examine whether borrowing constraints affect education decisions. The key issue is whether parents meet their expected family contribution. Children whose parents do not will have a harder time financing college than will other children. Issues may arise with any single specification we examine. But we have not been able to come up with a coherent alternative explanation to borrowing constraints for the empirical patterns we have documented. Specifically, close birth spacing is a strong predictor of college financial aid. Among the children of a parent who makes no post-schooling transfers, siblings with closer birth dates complete more education than their siblings with more isolated birth dates. Birth spacing does not matter for families making post-college transfers. The effects only appear for middle-wealth families who would be expected to not receive complete financial aid or no financial aid. The effects are larger during periods when more financial aid is available. Similar results arise when the sample is split based on an experimental proxy for parental altruism: Birth spacing has no effect on educational attainment of children with the most altruistic parents while spacing is significant for children with less altruistic parents. Birth spacing does not matter for children whose parents expect to make substantial bequests. It does for children whose parents do not. Finally evidence from the NLSY-97 is consistent with the HRS-based evidence: children in families whose parents do not meet their expected family contribution get less education than children from families that do. We think the evidence, taken together, supports the implications of the model where strategic concerns result in some parents investing less than the efficient level in their children's education.

IV. Conclusions

A student's federal assistance for college is determined based on their parents' presumed ability to pay, and standards for financial independence from parents are stringent. Parents are under no legal obligation to meet their expected contribution as specified in federal financial aid formulas. If parents refuse to pay, children may face financial constraints in attending college. According to their parents, a third of all children in the Health and Retirement Study who got some post-secondary education did so without their parents' financial assistance. This fact is not solely a consequence of need-based financial aid differences. A quarter of children whose parents held \$200,000-\$400,000 in net worth in 2000 attended college without parental support, as did 16 percent of those whose parents' net worth exceeded \$400,000. The scope for some students having financial difficulty in attending college appears quantitatively important.

Given this fact, we present a theory of efficient human capital investment, focusing on the roles of parent and child decisions and financial aid. The theory implies that financial aid increases the educational attainment of intergenerationally constrained children who receive no post-schooling gifts from their parents, but financial aid does not matter to the attainment of intergenerationally unconstrained children. These effects each rely on an asymmetry in the access of parents and their college-aged children to credit.

Estimates using data from the HRS support the model's predictions. Based on an idiosyncrasy in the dependence of U.S. financial aid on the number of children a parent has in college, we use years of overlap with college-age siblings as a proxy for financial aid. We find the educational attainment of children whose parents are not observed to make post-schooling cash gifts is affected by financial aid. The educational attainment of children whose parents do make gifts is not affected by financial aid. These results, along with a series of specification and robustness tests, suggest that parents can relieve educational borrowing constraints for their children, but that they do not always choose to do so.

Our empirical estimates are economically significant. The Table 2 point estimates imply that a twin with no other siblings in a family that does not make post-college transfers will complete, on average, 0.4 years more schooling than an only child, all else equal. This twin would receive roughly \$3,600 (in 2009 dollars) more financial aid than an otherwise identical student with their nearest sibling spaced five or more years apart (or without a sibling). It is impossible, however, to target aid to just those children whose parents do not make post-college transfers. Because about half the sample are children whose parents do not make post-college transfers, our estimates imply that \$3,600 in aid would generate, on average, 0.2 additional years of schooling. Using the simple, suggestive calculations described in the text, the return to this investment is around 17 percent.

A large, insightful prior literature documents empirical relationships that authors interpret as being consistent with educational borrowing constraints (see, for example, Manski and Wise, 1983; Hauser, 1993; Kane, 1994; Card, 1999; Kane and Rouse, 1999; Ellwood and Kane, 2000; Keane and Wolpin, 2001; Rothstein and Rouse, 2007; and, at least in data from the National Longitudinal Survey of Youth, 1997 cohort, Belley and Lochner, 2007). The same can be said for the papers that argue that U.S. educational credit markets are nearly complete by Cameron and Heckman (1998, 2001), Shea (2000), Carneiro and Heckman (2002), Cameron and Taber (2004), and Stinebrickner and Stinebrickner (2008).[54]

None of these papers, however, model explicitly how the interactions between parents and children may rationally lead to credit constraints for college, thus our paper offers a new perspective on this literature. Moreover, our framework suggests that research strategies that attempt to investigate the importance of credit constraints by examining the income gradient of college attendance or of educational attainment will be difficult to interpret. In our model, holding all else equal, educational attainment will vary *inversely* with parental resources for those intergenerationally constrained families where parents contribute nothing to their children's education. The explanation comes directly from financial aid rules. As parents' resources increase, the expected family contribution (EFC) increases. If children have parents who refuse or are unable to meet the EFC, the larger the unmet EFC, the more difficulty the child will have in financing college. For low-income families who get full financial aid, educational attainment will be non-decreasing with parental resources. Of course other factors, some likely

[54] Carneiro and Heckman (2002) find that up to 8 percent of the relevant U.S. population may be short-run credit constrained.

unobserved, may lead to a positive correlation between parental income and educational attainment. The relationship between parental income and their children's educational attainment will be difficult to interpret in empirical studies that mix families willing to meet and unwilling to meet their expected family contribution

Two features of the economic environment we construct cause students to have difficulties in financing their education when parents, for one reason or another, are unwilling or unable to make the expected family contribution. First, parents and children are unable to write binding contracts. Second, students cannot borrow against their future human capital. It is difficult to imagine having rules governing parent-child contracts changing in ways that are useful for alleviating credit constraints without also having more important undesirable consequences. It may be possible to relax restrictions students face on borrowing, particularly in cases where parents are unwilling (or unable) to cosign loans. Increases in financial aid for children whose parents are unwilling to meet their expected family contribution would increase educational attainment. At the same time, greater financial aid would likely reduce contributions made by families currently meeting (or exceeding) their expected family contribution. So policy-makers will need to grapple with this tradeoff – providing marginal subsidies for borrowing constrained students against infra-marginal subsidies to families willing to support their children's educational goals. Our evidence suggests that financial aid increases can increase educational attainment, though clearly at a cost that exceeds a perfectly targeted policy.

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Appendix A: Proofs

Constraints $a^k \geq 0$ and $e^k \geq 0$ both bind for the child if the parent chooses e^p, a^p and g_1 such that

$$u'(g_1) \geq \beta \max\left\{R, h'(e(e^p,\tau))\tfrac{\partial e}{\partial(e^p+e^k)}\right\}\left(1+\frac{\partial g_2}{\partial h(e(e^p,\tau))}\right)u'\left(h(e(e^p,\tau))+g_2(Ra^p,h(e(e^p,\tau))\right) \qquad (7)$$

Lemma 1: If $g_2 > 0$ in equilibrium, then it must be the case that $a^k = 0$.

The intuition behind lemma 1 is that, since both the parent and the child earn return *R* on physical capital investment, the parent who anticipates a positive second period gift will always prefer to save for the child. A formal proof of lemma 1 is available from the authors.

Lemma 2: In the first period, the parent can do no better than to choose (g_1, a^p, e^p) to maximize $\left\{u(c_1^p)+\beta u(c_2^p)+\alpha\left(u(g_1)+\beta u(c_2^k)\right)\right\}$ subject to $c_1^p + a^p + e^p + g_1 = x^p$, $c_2^p = Ra^p - g_2(Ra^p, h(e(e^p,\tau)))$, $c_2^k = h(e(e^p,\tau)) + g_2(Ra^p, h(e(e^p,\tau)))$, $g_2(Ra^p, h(e(e^p,\tau)))$ as in (1), and $e^k \geq 0$ and $a^k \geq 0$ binding for the child.

Assume an equilibrium consisting of

$$(e^p, a^p, g_1, e^k, a^k, g_2(Ra^p, Ra^k + h(e(e^p+e^k,\tau))))$$

where $e^k + a^k > 0$, and associated consumption levels

$$\{c_1^p, c_2^p, c_1^k, c_2^k\} = \{x^p - g_1 - e^p - a^p, Ra^p - g_2(Ra^p, Ra^k + h(e(e^p+e^k,\tau))),$$
$$g_1 - e^k - a^k, Ra^k + h(e(e^p+e^k,\tau)) + g_2(Ra^p, Ra^k + h(e(e^p+e^k,\tau)))\}.$$

We find that the parent can replicate the consumption paths of any such equilibrium by deviating from the equilibrium in period 1 to choose first period transfer $\tilde{g}_1 = g_1 - a^k - e^k$, savings $\tilde{a}^p = a^p + a^k$ and human capital investment $\tilde{e}^p = e^p + e^k$. In the deviation, constraints $e^k \geq 0$ and $a^k \geq 0$ bind for the child. This implies that the parent can replicate any feasible consumption path by choosing (g_1, a^p, e^p) in the first period such that $e^k \geq 0$ and $a^k \geq 0$ bind. Therefore the parent can do no better than to choose her most preferred period 1 (g_1, a^p, e^p) subject to $e^k \geq 0$ and $a^k \geq 0$ binding for the child. A formal proof of lemma 2 is available from the authors.

Proof of Proposition 1:

Proof Given Lemma 2, consider the parent's solution to

$$\max_{g_1, a^p, e^p} \left\{u(c_1^p)+\beta u(c_2^p)+\alpha\left(u(g_1)+\beta u(c_2^k)\right)\right\}$$

s.t. $c_1^p + a^p + e^p + g_1 = x^p$, $c_2^p = Ra^p - g_2(Ra^p, h(e(e^p,\tau)))$, (8)

$c_2^k = h(e(e^p,\tau)) + g_2(Ra^p, h(e(e^p,\tau)))$, $g_2(Ra^p, h(e(e^p,\tau)))$ as in (1),

and $e^k \geq 0$ and $a^k \geq 0$ binding for the child.

Recall that the requirement that condition (7) holds is equivalent to the requirement that $e^k \geq 0$ and $a^k \geq 0$ bind. Suppose that the parent is permitted to choose g_2 such that $u'(Ra^p - g_2) = \alpha u'(h(e(e^p,\tau)) + g_2)$, even if this implies $g_2 < 0$. Without imposing (7), the parent's choice of (g_1, a^p, e^p) meets conditions

$$\begin{aligned}&u'(c_1^p) = \alpha u'(g_1),\ u'(c_1^p) = \beta R u'(c_2^p),\ h'(e(e^p,\tau))\tfrac{\partial e}{\partial(e^p+e^k)} = R,\ u'(c_2^p) = \alpha u'(c_2^k),\\ &\text{where } c_1^p = x^p - g_1 - e^p - a^p,\ c_2^p = Ra^p - g_2,\ \text{and } c_2^k = h(e(e^p,\tau)) + g_2.\end{aligned} \tag{9}$$

Conditions (9) imply $u'(g_1) = \beta R u'(c_2^k)$. In transfer equation (1), $\dfrac{\partial g_2}{\partial(h(e))} \leq 0$. Given $h'(e(e^p,\tau))\frac{\partial e}{\partial(e^p+e^k)} = R$ in (9), it must be the case that

$$\begin{aligned}&u'(g_1) = \beta R u'(c_2^k)\\ &\Rightarrow u'(g_1) \geq \beta \max\{h'(e(e^p,\tau))\tfrac{\partial e}{\partial(e^p+e^k)}, R\}\left(1 + \frac{\partial g_2}{\partial(h(e(e^p,\tau)))}\right)u'(c_2^k)\end{aligned}$$

and therefore (7) is satisfied at the parent's preferred feasible (g_1, a^p, e^p). Conditions (9) are met by a unique set of consumption levels $\{c_1^p, c_2^p, c_1^k = g_1, c_2^k\}$. If conditions (9) can be met with $g_2 \geq 0$, then these consumption levels result from the parent's optimal actions given her resource constraints and the choices available to the child.

However, it is possible that conditions (9) cannot be met with $g_2 \geq 0$. Where $g_2 \geq 0$ binds for the parent, the solution to (8) is such that

$$\begin{aligned}&u'(c_1^p) = \alpha u'(g_1),\ u'(c_1^p) = \beta R u'(c_2^p),\ \ h'(e(e^p,\tau)) > R,\ u'(c_2^p) > \alpha u'(c_2^k),\\ &u'(g_1) = \beta h'(e(e^p,\tau)) u'(c_2^k),\\ &\text{where } c_1^p = x^p - g_1 - e^p - a^p,\ c_2^p = Ra^p, \text{ and } c_2^k = h(e(e^p,\tau)).\end{aligned} \tag{10}$$

Note that $h'(e(e^p,\tau))\frac{\partial e}{\partial(e^p+e^k)} > R$, $u'(g_1) = \beta h'(e(e^p,\tau))\frac{\partial e}{\partial(e^p+e^k)} u'(c_2^k)$, and $\dfrac{\partial g_2}{\partial(h(e(e^p,\tau)))} \leq 0$ together imply

$$\begin{aligned}u'(g_1) &= \beta h'(e(e^p,\tau))\tfrac{\partial e}{\partial(e^p+e^k)} u'(c_2^k)\\ &\geq \beta \max\{h'(e(e^p,\tau))\tfrac{\partial e}{\partial(e^p+e^k)}, R\}\left(1 + \frac{\partial g_2}{\partial(h(e(e^p,\tau)))}\right)u'(c_2^k),\end{aligned}$$

so that again (7) need not be imposed. Like conditions (9), conditions (10) are satisfied by a unique set of consumption levels $\{c_1^p, c_2^p, c_1^k = g_1, c_2^k\}$. In either case, Lemma 2 implies that the parent's lifetime welfare at this consumption vector, $u(c_1^p) + \beta u(c_2^p) + \alpha\left(u(c_1^k) + \beta u(c_2^k)\right)$, represents the maximum equilibrium welfare available to the parent given the resource constraints and the child's available choices. The uniqueness of the consumption levels that solve (8) implies that no other set of feasible consumption levels yields higher welfare for the parent, and therefore $\{c_1^p, c_2^p, c_1^k, c_2^k\}$ represents the family's unique equilibrium consumption, completing the proof of *(i)*.

We know, based on (9) and (10), that $\{c_1^p, c_2^p, c_1^k, c_2^k\}$ can be generated by only one set of parental choices $\{g_1, a^p, e^p, g_2\}$ at which $e^k \geq 0$ and $a^k \geq 0$ bind. It may still be the case, however, that this same consumption path can be supported by different transfers and investments where e^k and a^k take positive values. Define $\left\{c_1^p(0), c_2^p(0), c_1^k(0), c_2^k(0),\ g_1(0), a^p(0), e^p(0), g_2(0)\right\}$ as the values of $\left\{c_1^p, c_2^p, c_1^k, c_2^k, g_1, a^p, e^p, g_2\right\}$ in the only equilibrium in which $e^k + a^k = 0$. The parent transfers to the child through $g_1(0)$, $e^p(0)$, and $g_2(0)$. We seek to determine whether the same consumption is supported when the parent transfers some portion of $g_2(0)$ or $e^p(0)$ through g_1, expecting the child to save for herself or invest in her own education.
When $g_2(0) > 0$, the answer is clear. The child's choices of e^k and a^k meet condition (2) where $e^k + a^k > 0$. Whenever $g_2(0) > 0$, (1), (2), and $h'(e(e^p, \tau))\frac{\partial e}{\partial(e^p + e^k)} = R$ together imply $u'(c_1^k) < \beta R u'(c_2^k)$. However, among conditions (9) is the requirement that $u'(c_1^k) = \beta R u'(c_2^k)$. Thus whenever $g_2(0) > 0$, the parent and the child disagree on the child's optimal intertemporal consumption path. Allowing the child to save independently or invest in her own education will lead to consumption other than $\{c_1^p(0), c_2^p(0), c_1^k(0), c_2^k(0)\}$. Thus the $e^k + a^k = 0$ equilibrium is the only set of actions that supports the parent's preferred $\{c_1^p, c_2^p, c_1^k, c_2^k\}$. The parent chooses $\{g_1, a^p, e^p, g_2\} = \{g_1(0), a^p(0), e^p(0), g_2(0)\}$ as in (3) in this unique equilibrium, imposing $e^k + a^k = 0$ and $h'(e(e^p, \tau))\frac{\partial e}{\partial(e^p + e^k)} = R$. This completes the proof of *(ii)*.

When $g_2(0) = 0$, however, the parent may reallocate transfers and still achieve $\{c_1^p(0), c_2^p(0), c_1^k(0), c_2^k(0)\}$. Only the reallocation of e^p to g_1 must be considered. Define $\underline{e}$ such that $u'(Ra^p(0)) = \alpha u'(h(e(\underline{e}, \tau)))$. Suppose that the parent increases g_1 to $g_1 = g_1(0) + \varepsilon$, where $\varepsilon \in \left(0, e^p(0) - \underline{e}\right]$, while maintaining $a^p = a^p(0)$ and $g_1 + e^p = g_1(0) + e^p(0)$. Since $e^p \geq \underline{e}$, the second period transfer is still zero. Further, the child's choice of $e^k = 0$ given $\left(g_1(0), a^p(0), e^p(0)\right)$ implies that she chooses an e^k at which $e^p + e^k \leq e^p(0)$ given $\left(g_1(0) + \varepsilon, a^p(0), e^p(0) - \varepsilon\right)$. Therefore, by conditions (10), $h'(e(e^p + e^k, \tau))\frac{\partial e}{\partial(e^p + e^k)} > R$ and the child's condition (2) determining her choice of e^k reduces to

$$u'(c_1^k) = \beta h'(e(e^p + e^k, \tau))\frac{\partial e}{\partial(e^p + e^k)} u'(c_2^k).$$

Since the above agrees with the intertemporal condition on the child's consumption in (10), we see that the parent's reallocation of $\varepsilon \in \left(0, e^p(0) - \underline{e}\right]$ from e^p to g_1 results in the same equilibrium $\{c_1^p(0), c_2^p(0), c_1^k(0), c_2^k(0)\}$. Finally, condition (2) and the definition of $\underline{e}$ together indicate that where p reallocates $\varepsilon \in \left(e^p(0) - \underline{e}, e^p(0)\right]$ from e^p to g_1 the child's educational investment may or may not be such that conditions (10) hold. Therefore where $g_2(0) = 0$ there

does exist a continuum of equilibria
$\{g_1, a^p, e^p, a^k, e^k\} \in \left[\{g_1(0), a^p(0), e^p(0), 0, 0\}, \{g_1(0) + e^p(0) - \underline{e}, a^p(0), \underline{e}, 0, e^p(0) - \underline{e}\}\right]$ that support the unique equilibrium values of $\{c_1^p, c_2^p, c_1^k, c_2^k\}$, and there may exist further equilibria $\{g_1, a^p, e^p, a^k, e^k\} \in \left[\{g_1(0) + e^p(0) - \underline{e}, a^p(0), \underline{e}, 0, e^p(0) - \underline{e}\}, \{g_1(0) + e^p(0), a^p(0), 0, 0, e^p(0)\}\right]$ that support the unique equilibrium values of $\{c_1^p, c_2^p, c_1^k, c_2^k\}$. Each possible equilibrium satisfies (10) and therefore implies $h'(e(e^p + e^k, \tau)) \frac{\partial e}{\partial (e^p + e^k)} > R$, completing the proof of *(iii)*.

Proof of Proposition 2*:* Proof of *(i)* and *(ii)*, assuming $e(e^p + e^k, \tau) = (1+\tau)(e^p + e^k)$:
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Recall from conditions (3) for the $g_2 > 0$ equilibrium that $h'(e) \frac{\partial e}{\partial (e^p + e^k)} = R$. Where $e(e^p + e^k, \tau) = (1+\tau)(e^p + e^k)$, this implies

$$h'(e)(1+\tau) = R.$$

Differentiating with respect to τ,

$$\frac{\partial\left[h'(e)(1+\tau)\right]}{\partial \tau} = 0$$

$$\Rightarrow h''(e)\frac{\partial e}{\partial \tau}(1+\tau) + h'(e) = 0.$$

Rearranging,

$$\frac{\partial e}{\partial \tau} = \frac{-h'(e)}{h''(e)(1+\tau)}.$$

Thus the $g_2 > 0$ equilibrium conditions (3) imply $\frac{\partial e}{\partial \tau} = \frac{-h'(e)}{h''(e)(1+\tau)}$ > 0, proving *(i)*. (Note that the net rate of return on educational investment is $h'(e)(1+\tau)$. As long as the primitive parameters of the problem are such that $g_2 > 0$ in equilibrium, a change in τ does not change the return to the marginal human capital investment realized by the family.)

Given the above,

$$\frac{\partial e}{\partial \tau} > \frac{-h'(e)}{h''(e)(1+\tau)}$$

$$\Rightarrow \frac{\partial\left[h'(e)(1+\tau)\right]}{\partial \tau} < 0.$$

The proposition implies that, as long as the primitive parameters of the problem are such that $g_2 = 0$ in equilibrium, the net return to the marginal educational investment decreases with a hike in financial aid. We must demonstrate that the constrained, no gift family uses an increase in price subsidy financial aid to move their marginal return to educational investment, $h'(e)(1+\tau)$, downward toward the (fixed and exogenous) return to physical capital investment, *R*. This has the effect of closing the rate of return gap $h'(e)(1+\tau) > R$ that intergenerationally constrained parents tolerate as a part of the $g_2 = 0$ equilibrium conditions expressed in (4).

Proof of *(iii)* and *(iv)*, assuming $e(e^p + e^k, \tau) = e^p + e^k + \tau$: In the $g_2 > 0$ equilibrium,

$$h'(e^p + e^k + \tau) = R$$
$$\Rightarrow e^p + e^k = h'^{-1}(R) - \tau.$$

Since $h'^{-1}(R)$ is a fixed and exogenous level of investment, $\dfrac{\partial(e^p + e^k)}{\partial \tau} = -1$ and total educational investment is invariant to the child's financial aid, completing the proof of *(iii)*.

The $g_2 = 0$ equilibrium requires only that $h'(e^p + e^k + \tau) > R$, and in it only $G_1 = g_1 + e^p$ is determined. Recall that $e = e^p + e^k + \tau$. Suppose $\dfrac{\partial(e^p + e^k)}{\partial \tau} \leq -1$. Then $\dfrac{\partial e}{\partial \tau} \leq 0$, $\dfrac{\partial c_2^k}{\partial \tau} = \dfrac{\partial h(e)}{\partial \tau} \leq 0$ and $u'(c_1^k) = \beta h'(e) u'(h(e))$ from conditions (4) for the $g_2 = 0$ equilibrium implies $\dfrac{\partial c_1^k}{\partial \tau} \leq 0$. With $u'(c_1^p) = \alpha u'(c_1^k)$ and $u'(c_1^p) = \beta R u'(c_2^p)$ from conditions (4), $\dfrac{\partial c_1^k}{\partial \tau} \leq 0$ implies $\dfrac{\partial c_1^p}{\partial \tau} \leq 0$ and $\dfrac{\partial c_2^p}{\partial \tau} \leq 0$. Together these conditions imply $c_1^p + \dfrac{c_2^p}{R} + c_1^k + h^{-1}(c_2^k)$ is (weakly) decreasing in τ, contradicting the implication of $c_2^p = Ra^p$, $c_2^k = h(e)$ and the combined asset constraints of the problem that $c_1^p + \dfrac{c_2^p}{R} + c_1^k + h^{-1}(c_2^k) = x^p + \tau$. Therefore $\dfrac{\partial(e^p + e^k)}{\partial \tau} > -1$ in the $g_2 = 0$ equilibrium, completing the proof of *(iv)*.

Appendix B: An Economic Environment with Greater Realism

In this appendix we extend the baseline model, allowing uncertain earnings and the child to borrow at a higher interest rate than the parent, and we explicitly model the human capital production function of the child, which allows us to model a child's decision to work while in college. We show the central result from our simple model in the text holds: financial aid will have a larger effect on the educational attainment of children from families that do not make financial transfers in the second period ($g_2 = 0$ families) compared to children from families that do make second period transfers ($g_2 > 0$ families). Since we now consider a stochastic version of the model, we can no longer say that all children in the $g_2 = 0$ sample will be constrained in their human capital investment decisions. Instead, we show these children are significantly more likely to under-invest in their human capital than children in the $g_2 > 0$ sample.

We start by assuming the child faces uncertainty in future earnings. The child solves

$$\max\left\{u(c_1^k, l_1^k) + \beta \int u(c_2^k, l_2^k) d\Theta(\theta)\right\},$$

subject to

$$c_1^k + a^k + e^k = g_1 + w(1 - l_1^k - n^k),$$

and

$$c_2^k = R(a^k) + \theta w(1 - l_2^k) h(n^k, e^p + e^k + \tau) + g_2,$$

where the function R is given by

$$R(a^k) = \begin{cases} Ra^k, \text{ if } a^k \geq 0 \\ R'a^k, \text{ if } a^k < 0 \end{cases}.$$

We assume that the rate at which children can borrow R' exceeds the market rate of return R.

In the above formulation, l stands for leisure, n denotes time spent in college, w stands for the wage rate, and θ denotes uncertainty in labor earnings. While the child experiences the same rate of return to savings, R, as does the parent, the cost of borrowing against his or her own future earnings is higher and is denoted by R'. We assume that the distribution from which shocks are drawn is the same for all levels of human capital.[55]

The parent cares about the child, so the parent's decision problem is given by

$$\max\left\{v(c_1^p) + v(c_2^p) + \alpha\left[u(c_1^k, l_1^k) + \beta \int u(c_2^k, l_2^k) d\Theta(\theta)\right]\right\}$$

subject to

$$c_1^p + a^p + e^p + g_1 = x^p$$

[55] If we assumed highly educated households face less uncertainty about their future earnings, we would be more likely to find that parents who do not follow up with post-schooling gifts under-invest in their children's education.

and

$$c_2^p + g_2 = Ra^p$$

The model is now substantially more complicated than before – there are many more choice variables, and uncertainty in earnings breaks the one-for-one link between efficient investment in human capital and second period cash gifts. Hence, this economic environment needs to be solved numerically.

Parameterization

We assume that children's preferences are Cobb-Douglas between consumption and leisure, i.e. $u(c,l) = \frac{\left[c^{\eta} l^{1-\eta}\right]^{1-\theta}}{1-\theta}$ where $0 < \eta < 1$ determines the relative taste for consumption versus leisure. Cobb-Douglas preferences are widely used in the macro literature, since they are consistent with balanced growth, irrespective of the choice for θ. Moreover, this specification implies non-separability between consumption and leisure, which is consistent with some microeconomic empirical evidence (for example, Heckman, 1974). The parameter η can be identified by the share of disposable time people devote to market work. A typical value for η is $\frac{1}{3}$. Our preferences imply that the parameter θ governs both the intertemporal elasticity of substitution for consumption and the corresponding elasticity for hours worked. In particular, the intertemporal elasticity of substitution for consumption is $\frac{1}{\theta}$. A standard value for θ is 4. The coefficient of relative risk aversion is then $1-\eta+\eta\theta$. Our parameters imply a risk aversion coefficient of 2 and a Frisch labor supply elasticity of 1. We experiment with η between 0.1 and 0.5 and θ between 1 and 6. These cover the range of available estimates for the labor supply elasticity and risk aversion.

Our human capital production function is parameterized as $h(n,e) = zn^{\gamma_1}e^{\gamma_2}$. Time and goods inputs are combined with ability, z, to produce human capital. This specification follows the pioneering work of Ben Porath (1967). There are numerous papers that estimate the parameters γ_1 and γ_2. A prominent set of estimates suggest that the returns to scale in the human capital production function, $\gamma = \gamma_1 + \gamma_2$ are 0.9 or higher (see Browning, Hansen and Heckman, 1999).[56] In our baseline parameterization we assume that $\gamma = 0.9$ and $\gamma_2 = 0.3$. Finally, we assume that R equals 5 percent while R' equals 10 percent. Here, we have in mind uncollaterized loans such as credit card loans that typically come with an interest rate well above 10 percent. Higher values of R' would make our results stronger.

[56]If $\gamma_2 = 0$, expenditures do not affect human capital production

The distribution of earnings after college is the result of two underlying sources of heterogeneity. First, children are different on the basis of their ability before college. This reflects both innate differences in children as well as differences in acquired human capital before college. Second, earnings are also affected by luck shocks that the child realizes after completing college. Two moments are used to parameterize the two distributions – the distribution of schooling and the distribution of earnings. We obtain this information from the Health and Retirement Study.

Results

As we have noted several times, uncertainty breaks the tight link between the optimality (from the child's perspective) of first period education transfers and second period financial transfers. Given this, our strategy is to split the sample into those who do give gifts and those who do not and then examine whether families who do not pass on gifts are more likely to under-invest.

In the baseline specification of preferences, we find that 69 percent of families who do not pass on gifts in the second period, under-invest in college education. In contrast, only 17 percent of families who do end up with positive post-schooling cash transfers under-invest in their children's education.

It is instructive to examine the implications of two assumptions – the possibility of borrowing while in college and work while in college. If we assume that work while in college is not possible and that the child cannot borrow against future income, then the fraction of households (with zero gifts) that under-invest increases to 87 percent from 69 percent. This suggests that while both these options relieve borrowing constraints, a substantial fraction of parents who do not give gifts still have children who are unable to get the efficient level of education, even when work and high-cost borrowing are available. As mentioned earlier, we also experiment with a range of parameter values, allowing η to vary between 0.1 and 0.5 and θ to vary between 1 and 6. Then the fraction of households with zero gifts that under-invests ranges from 59 percent to 91 percent depending on parameter values, and this fraction is always substantially higher than the group that does give gifts.

These results add to our confidence that the main implications of our simple model stand up to further scrutiny. This is perhaps not all that surprising since the results depend on straightforward assumptions – parents are altruistic, children cannot borrow against future human capital, parents and children cannot write binding contracts, and human capital production is subject to diminishing returns. The assumptions (along with optimizing behavior) will lead parents to equate the marginal return to investing in education to the real financial market rate of return. Parents who get to this margin will then give post-college gifts. Parents who do not, will be significantly less likely to give post-college gifts.

Table 1: Child-Level Descriptive Statistics for the Health and Retirement Study Samples

Variable	Sample	Sample size	Mean	Median	Standard deviation
Parent made any gift to children, 1998-2004	1998-2004 Cores	34,593	0.4888	0.0000	0.50
Parent ever made major gift to child	1994 Module	1262	0.3700	0.0000	0.4988
Parent's 2000 household income	2000 Core	34,593	$42,155	$25,588	$64,439
	1994 Module	1262	$48,975	$35,000	$49,734
Parent's 2000 household net worth	2000 Core	34,593	$299,689	$111,000	$799,255
	1994 Module	1262	$309,531	$149,950	$571,914
Child years of education	2000 Core	34,593	13.80	13.00	6.875
	1994 Module	1262	13.30	12.00	2.194
Child gender (male = 1)	2000 Core	34,593	0.5004	1.0000	0.5000
	1994 Module	1262	0.4857	0.0000	0.5000
Child age in 2000	2000 Core	34,593	41.82	41.00	9.64
	1994 Module	1262	40.73	41.00	6.45
Oldest child indicator	2000 Core	34,593	0.2856	0.0000	0.4517
	1994 Module	1262	0.2647	0.0000	0.4413
Youngest child indicator	2000 Core	34,593	0.2617	0.0000	0.4395
	1994 Module	1262	0.2361	0.0000	0.4249
Years of overlap with siblings' college ages	2000 Core	34,593	2.337	2.000	2.130
	1994 Module	1262	2.631	2.000	2.141

Note: Sample children are aged 24 and older.

Table 2: Family Fixed Effect Estimates of Years of Schooling, HRS, Gift v. No Gift

	1998-2004 Gifts to Children		Transfer Module Gifts to Children	
	Gifts	No Gifts	Gifts	No Gifts
Independent variable	**Parameter (Std error)**	**Parameter (Std error)**	**Parameter (Std error)**	**Parameter (Std error)**
Child gender, male=1	-0.242***	-0.086	-0.249	-0.314**
	(0.087)	(0.088)	(0.195)	(0.134)
Child age	-0.014	-0.048***	-0.008	-0.051***
	(0.013)	(0.012)	(0.029)	(0.018)
Oldest child indicator	0.147	0.296**	0.079	0.290
	(0.117)	(0.121)	(0.258)	(0.186)
Youngest child indicator	0.119	-0.089	0.187	-0.056
	(0.124)	(0.126)	(0.265)	(0.194)
Sibling-years of overlap	0.034	0.105***	-0.050	0.094**
in college ages	(0.031)	(0.030)	(0.064)	(0.046)
Number of Children	16,892	17,701	467	795
Number of Families	4890	4581	125	209
R-squared	0.5934	0.6521	0.5713	0.5941
Adjusted R-squared	0.4276	0.5304	0.4073	0.4454

* indicates significance at the 10 percent, ** at the 5 percent, and *** at the 1 percent level.

Table 3: Family Fixed Effect Estimates of Years of Schooling, HRS

	1998-2004 Gifts to Children		Transfer Module Gifts to Children	
	Gifts	No Gifts	Gifts	No Gifts
Independent variable	**Parameter (Std error)**	**Parameter (Std error)**	**Parameter (Std error)**	**Parameter (Std error)**
Child gender, male=1	-0.241**	-0.088	-0.341	-0.379*
	(0.0878)	(0.089)	(0.0204)	(0.153)
Child age	0.014	-0.048**	-0.014	-0.067**
	(0.013)	(0.012)	(0.029)	(0.023)
Oldest child indicator	0.145	0.297*	0.094	0.331
	(0.117)	(0.121)	(0.273)	(0.216)
Youngest child indicator	0.119	-0.089	0.547	-0.274
	(0.125)	(0.127)	(0.286)	(0.224)
Sibling-years of overlap	0.020	0.070	0.048	0.071
in college ages*Tercile 1	(0.045)	(0.046)	(0.103)	(0.063)
Sibling-years of overlap	0.048	0.189**	0.060	0.197*
in college ages*Tercile 2	(0.051)	(0.047)	(0.083)	(0.082)
Sibling-years of overlap	0.040	0.046	-0.044	-0.047
in college ages*Tercile 3	(0.055)	(0.054)	(0.128)	(0.114)
Number of Children	16,824	17,609	364	582
Number of Families	4869	4557	92	150
R-squared	0.59	0.65	0.59	0.57
Adjusted R-squared	0.43	0.53	0.44	0.41

* significant at 5%; ** significant at 1%

Table 4: Family Fixed Effect Estimates of Years of Schooling, HRS, Around Reform

College Entry	**Pre-reform**		**Post-reform**	
1998-2004 Gifts to Children	**Gifts**	**No Gifts**	**Gifts**	**No Gifts**
Independent variable	**Parameter (Std Error)**	**Parameter (Std Error)**	**Parameter (Std Error)**	**Parameter (Std Error)**
Child gender, male=1	-0.0707	-0.146	-0.443**	-0.0104
	(0.113)	(0.121)	(0.142)	(0.157)
Child age	0.00553	-0.0610**	-0.00152	-0.0211
	(0.0191)	(0.0182)	(0.0296)	(0.0327)
Oldest child indicator	0.128	0.338*	0.204	0.229
	(0.145)	(0.159)	(0.201)	(0.242)
Youngest child indicator	0.0184	-0.164	0.258	0.0487
	(0.172)	(0.187)	(0.196)	(0.215)
Sibling-years of overlap	-0.231**	0.239**	0.111	-0.0145
in college ages*Tercile 1	(0.0688)	(0.0684)	(0.0656)	(0.0829)
Sibling-years of overlap	0.0710	0.143*	0.0403	0.284**
in college ages*Tercile 2	(0.0716)	(0.0670)	(0.0828)	(0.0874)
Sibling-years of overlap	-0.0296	0.0692	0.114	0.0533
in college ages*Tercile 3	(0.0745)	(0.0758)	(0.0929)	(0.0974)
Number of Children	8180	11,036	8712	6636
Number of Families	3133	3579	3416	2623
R-squared	0.7339	0.6559	0.6248	0.7327
Adjusted R-squared	0.5682	0.4903	0.3821	0.5572

* significant at 5%; ** significant at 1%

Table 5: Family Fixed Effect Estimates of Years of Schooling, HRS 2000 Economic Altruism Module

	Altruism Module
Independent variable	**Parameter (Std error)**
Child gender, male=1	-0.0877
	(0.203)
Child age	-0.0464
	(0.0313)
Oldest child indicator	0.581*
	(0.276)
Youngest child indicator	0.134
	(0.286)
Sibling-years of overlap	0.0982
in college ages*Give 3/4	(0.0894)
Sibling-years of overlap	0.644**
in college ages*Give 1/2	(0.109)
Sibling-years of overlap	0.398*
in college ages*Never give	(0.157)
Number of Children	3292
Number of Families	914
R-squared	0.3035
Adjusted R-squared	0.0332

* significant at 5%; ** significant at 1%

Table 6: Family Fixed Effect Estimates of Years of Schooling,
Bequest Measures from HRS 1994 Economic Altruism Module & HRS 2000 Core

	Altruism Module	**HRS 2000 Core**
Independent variable	**Parameter (Std error)**	**Parameter (Std error)**
Child gender, male=1	-0.0801	-0.196**
	(0.247)	(0.0755)
Child age	-0.0738*	-0.0127
	(0.0367)	(0.0111)
Oldest child indicator	0.224	0.299**
	(0.335)	(0.102)
Youngest child indicator	-0.0123	0.600
	(0.354)	(0.107)
Sibling-years of overlap in college ages*bequest very important	0.0552	--
	(0.165)	
Sibling-years of overlap in college ages*bequest somewhat or not at all important	0.186**	--
	(0.0868)	
Sibling-years of overlap in college ages*100,000 bequest Pr >= 50%	--	0.0466
		(0.0347)
Sibling-years of overlap in college ages*100,000 bequest Pr < 50%	--	0.109**
		(0.0336)
Number of Children	3292	23,326
Number of Families	568	7628
R-squared	0.3035	0.5458
Adjusted R-squared	0.0332	0.3248

* significant at 5%; ** significant at 1%

Table 7: Probit Estimates (Marginal Effects) of College Completion, NLSY-97

	Respondents Whose Parent(s) Don't Pay for College, EFC>0
Independent variable	**Parameter (SE)**
Parent's 1997 income, 1000s	-0.002* (0.001)
Parent's 1997 income squared, 10000s	0.001** (0.000)
AFQT percentile	0.002*** (0.000)
Mother's education <HS	0.023 (-0.012)
Mother HS grad	-0.012 (0.023)
Number of siblings	-0.004 (0.007)
Female	0.069*** (0.023)
Black	-0.011 (0.030)
Hispanic	0.034 (0.037)
Broken home	-0.022 (0.022)
Urban	-0.045 (0.029)
South	-0.004 (0.024)
12 years old in 1997 wave	-0.117*** (0.019)
13 years old in 1997 wave	-0.071*** (0.022)
14 years old in 1997 wave	-0.032 (0.025)
15 years old in 1997 wave	-0.011 (0.028)
Observations	501
Pseudo R-squared	0.172

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 8: OLS Estimates of Highest Grade Completed, NLSY-97

Independent variable	Parameter (Std error)
Parent's 1997 income, 1000s	0.012***
	(0.002)
Parent's 1997 income squared, 10000s	-0.004***
	(0.001)
Parent's 1997 net worth, 1000s	0.000*
	(0.000)
AFQT percentile	0.018***
	(0.001)
Mother's education <HS	-0.062
	(0.127)
Mother HS grad	-0.060
	(0.079)
Number of siblings	-0.045**
	(0.021)
Female	0.284***
	(0.066)
Black	0.422***
	(0.107)
Hispanic	0.124
	(0.107)
Broken home	-0.287***
	(0.077)
Urban	-0.047
	(0.075)
South	0.019
	(0.071)
12 years old in 1997 wave	-1.397***
	(0.121)
13 years old in 1997 wave	-0.992***
	(0.124)
14 years old in 1997 wave	-0.281**
	(0.129)
15 years old in 1997 wave	-0.078
	(0.143)
Funding gap in first term of college, 100s	-0.014***
	(0.003)
Constant	13.298***
	(0.205)
Observations	1338
R-squared	0.328

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 1: HRS Sample Construction

Full HRS 2000 sample, with 1998-2004 gift data	
Initial number of households	13,091
Number of children of these households	40,667
Of these, children with complete age and education data	37,875
Of these, children aged 24 and over	36,353
Of these, children with complete gender and relationship data	36,351
Of these, children with at least 1 sibling	34,610
Of these, have 1998-2004 gift data	34,593
Number of families represented by remaining children	9,471
HRS Wave 2 Module 7 sample	
Initial number of module respondents	827
Number of families represented by the respondents	427
Number of children in the above families	1542
Of these, children with complete age data on all siblings	1536
Of these, children who are 24 and older	1458
Of these, children with gift data	1444
Of these, children with complete education, gender and relationshi	1362
Of these, children with at least 1 sibling	1262
Number of families represented by remaining children	334

Appendix Table 2: OLS Estimates of Financial Aid, NLSY-97

Independent variable	Parameter (Std error)
Sibling-years of overlap in first term of college	358.44**
	(179.52)
Parent's 1997 income, 1000s	-23.84***
	(6.38)
Parent's 1997 income squared, 10000s	7.14***
	(2.33)
Parent's 1997 net worth, 1000s	-2.19**
	(0.98)
Parent's 1997 net worth squared, 10000s	0.06*
	(0.03)
AFQT percentile	-28.97*
	(16.69)
AFQT percentile squared	0.63***
	(0.15)
Constant	3,152.17***
	(463.69)
Observations	2608
R-squared	0.06

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 3: OLS Estimates of AFQT percentile, NLSY-97

Independent variable	**Parameter (Std error)**
Sibling-years of overlap in college ages	-0.51**
	(0.22)
Mother's education <HS	-18.13***
	(1.09)
Mother HS grad	-9.51***
	(0.86)
Parent's 1997 income, 1000s	0.24***
	(0.02)
Parent's 1997 income squared, 10000s	-0.07***
	(0.01)
Zero siblings	3.62**
	(1.49)
One sibling	1.88**
	(0.94)
Three siblings	-0.16
	(1.12)
Four siblings	-2.06
	(1.44)
Five or more siblings	-4.36***
	(1.46)
Female	2.81***
	(0.71)
Black	-19.43***
	(0.99)
Hispanic	-10.88***
	(1.09)
Broken home	-3.17***
	(0.83)
Urban	1.95**
	(0.86)
South	0.14
	(0.79)
Constant	50.66***
	(1.68)
Observations	4597
R-squared	0.32

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix Table 4: Descriptive Statistics for the NLSY-97 Estimation Samples

	Respondents Whose Parent(s) Don't Pay for College, EFC>0 (501 observations)			Respondents Who Enroll in at Least One Term of College (1,338 observations)		
Variable Name	**Mean**	**Median**	**Std. Dev.**	**Mean**	**Median**	**Std. Dev.**
Completed college	0.11	0.00	0.32	**	**	**
Highest grade completed	**	**	**	14.14	14.00	1.42
Parent's 1997 income, 1000s	48.21	42.00	31.12	60.95	52.10	47.45
Parent's 1997 net worth, 1000s	**	**	**	195.97	75.40	457.76
AFQT percentile	53.51	53.75	25.49	61.07	64.76	26.29
Mother's education <HS	0.15	0.00	0.36	0.10	0.00	0.31
Mother HS grad	0.38	0.00	0.49	0.33	0.00	0.47
Mother some college	0.47	0.00	0.50	0.57	1.00	0.50
Number of siblings	2.26	2.00	1.54	2.05	2.00	1.52
Female	0.52	1.00	0.50	0.56	1.00	0.50
Black	0.24	0.00	0.43	0.20	0.00	0.40
Hispanic	0.17	0.00	0.38	0.14	0.00	0.35
Broken home	0.47	0.00	0.50	0.40	0.00	0.49
Urban	0.72	1.00	0.45	0.73	1.00	0.44
South	0.33	0.00	0.47	0.34	0.00	0.47
12 years old in 1997 wave	0.20	0.00	0.40	0.21	0.00	0.41
13 years old in 1997 wave	0.20	0.00	0.40	0.25	0.00	0.43
14 years old in 1997 wave	0.21	0.00	0.41	0.21	0.00	0.41
15 years old in 1997 wave	0.21	0.00	0.41	0.17	0.00	0.38
16 years old in 1997 wave	0.17	0.00	0.38	0.16	0.00	0.37
Funding gap in first term of college, 100s	**	**	**	12.74	5.60	14.51

Appendix Table 5: NLSY Sample Construction

Respondents Whose Parent(s) Don't Pay for College, EFC>0	
Initial number of respondents	8,984
Of these, respondents with non-missing college enrollment data in 2004	7,379
Of these, respondents with at least one term of college experience as of 2004	4,241
Of these, respondents with non-missing parental income data from 1997	3,159
Of these, respondents whose have families have EFC>0	2,709
Of these, respondents whose parents do not pay for college	661
Of these, respondents with non-missing AFQT score	574
Of these, respondents with non-missing mother's education data	547
Of these, respondents with non-missing number of siblings data	518
Of these, respondents with non-missing urban/rural residence data	501
Respondents Who Enroll in at Least One Term of College	
Initial number of respondents	8,984
Of these, respondents with non-missing college enrollment data in 2004	7,396
Of these, respondents with at least one term of college experience as of 2004	4,263
Of these, respondents for whom EFC in first college term can be imputed	1,912
Of these, respondents with non-missing parental transfers data	1,721
Of these, respondents with non-missing parental net worth data from 1997	1,639
Of these, respondents with non-missing AFQT score	1,423
Of these, respondents with non-missing mother's education data	1,391
Of these, respondents with non-missing number of siblings data	1,389
Of these, respondents with non-missing urban/rural residence data	1,338